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Ushigome

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(54) **SHAPING DEVICE AND PRODUCTION METHOD FOR SHAPED OBJECT**

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B29C 59/04	(2006.01)
B29C 35/08	(2006.01)
B29C 35/00	(2006.01)

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(58) **Field of Classification Search**

CPC B29C 2035/0283; B29C 2035/0822; B29C 44/022; B29C 44/28; B29C 44/285; B29C 44/30; B29C 44/302; B29C 44/304; B29C 44/306; B29C 44/308; B29C 44/3415; B29C 35/0805; B29C 2795/002; B32B 5/18

See application file for complete search history.

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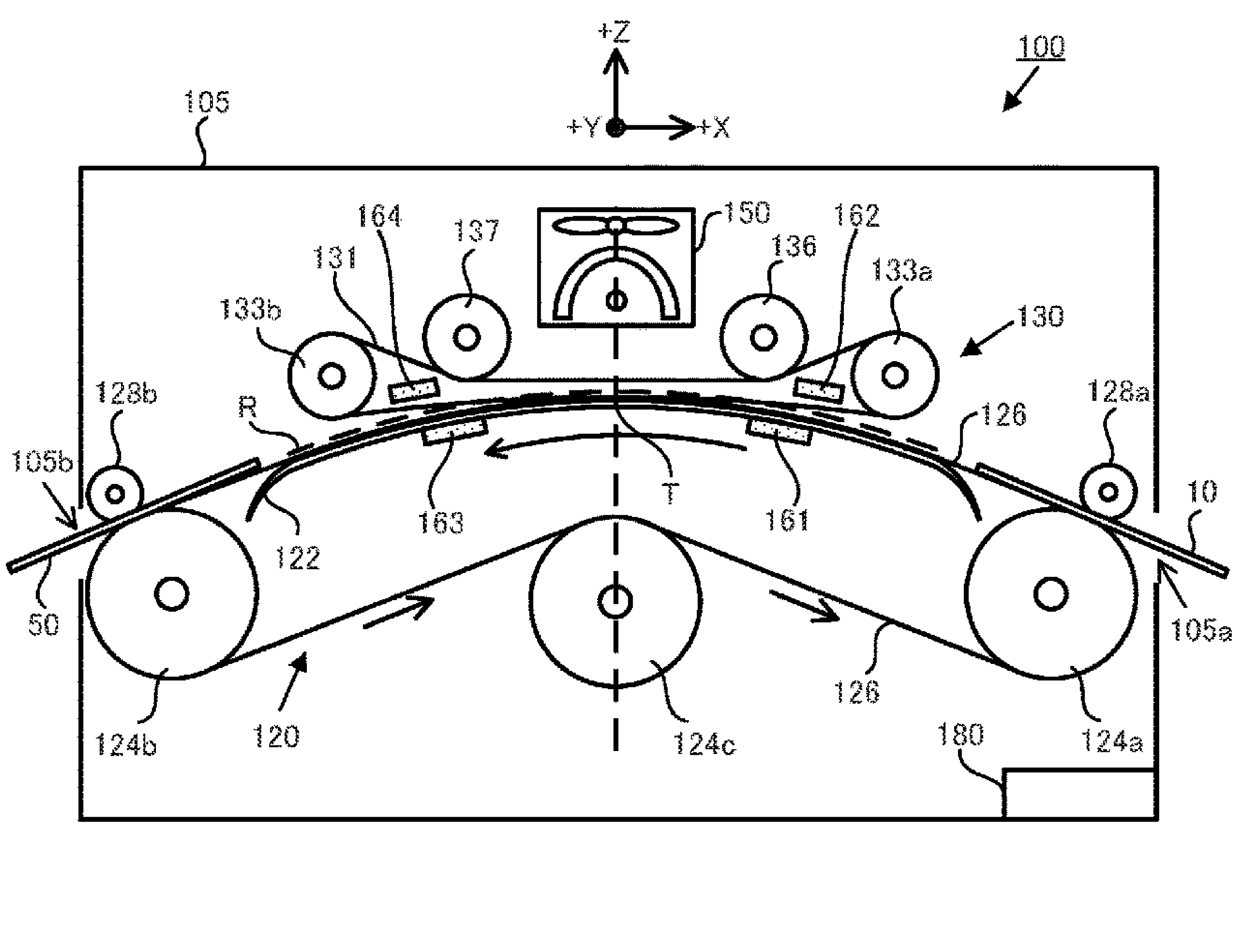
(74) *Attorney, Agent, or Firm* — Holtz, Holtz & Volek PC

(57) **ABSTRACT**

In a shaping device, a sheet that distends due to being irradiated with electromagnetic waves is placed a conveyor belt. An irradiator irradiates the sheet placed on and conveyed by the conveyor belt with electromagnetic waves. At least one heater heats the conveyor belt.

19 Claims, 7 Drawing Sheets



(51) **Int. Cl.**

B29C 35/10	(2006.01)
B29C 35/04	(2006.01)
B41M 7/00	(2006.01)
B29C 35/02	(2006.01)
B29C 35/16	(2006.01)

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FIG. 1

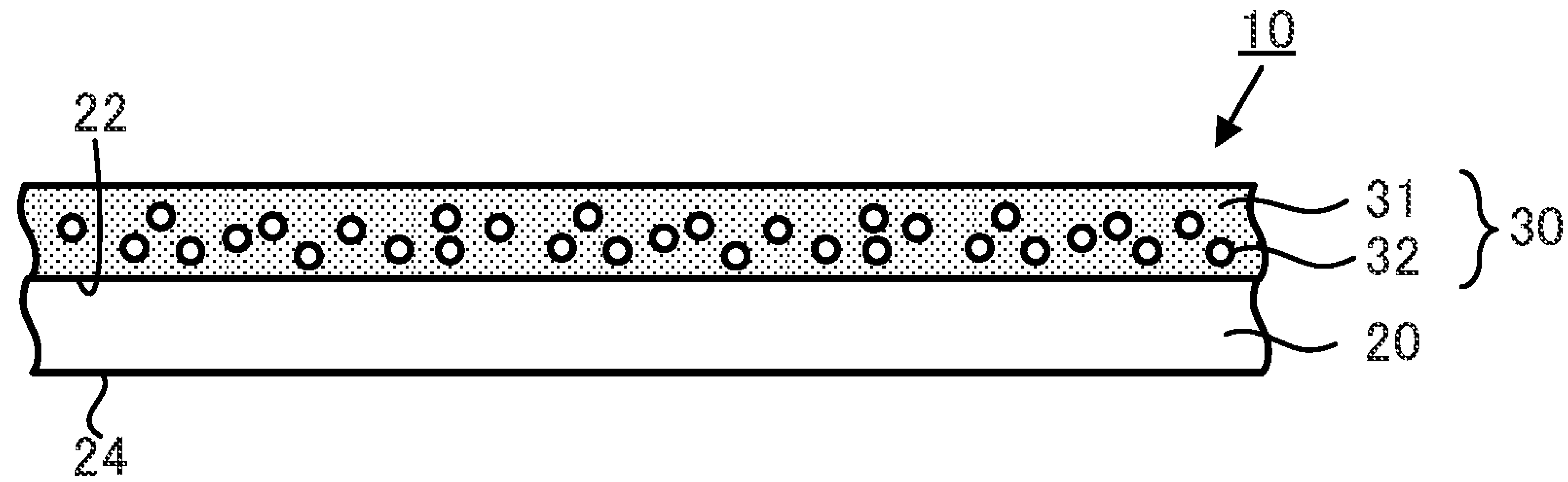


FIG. 2

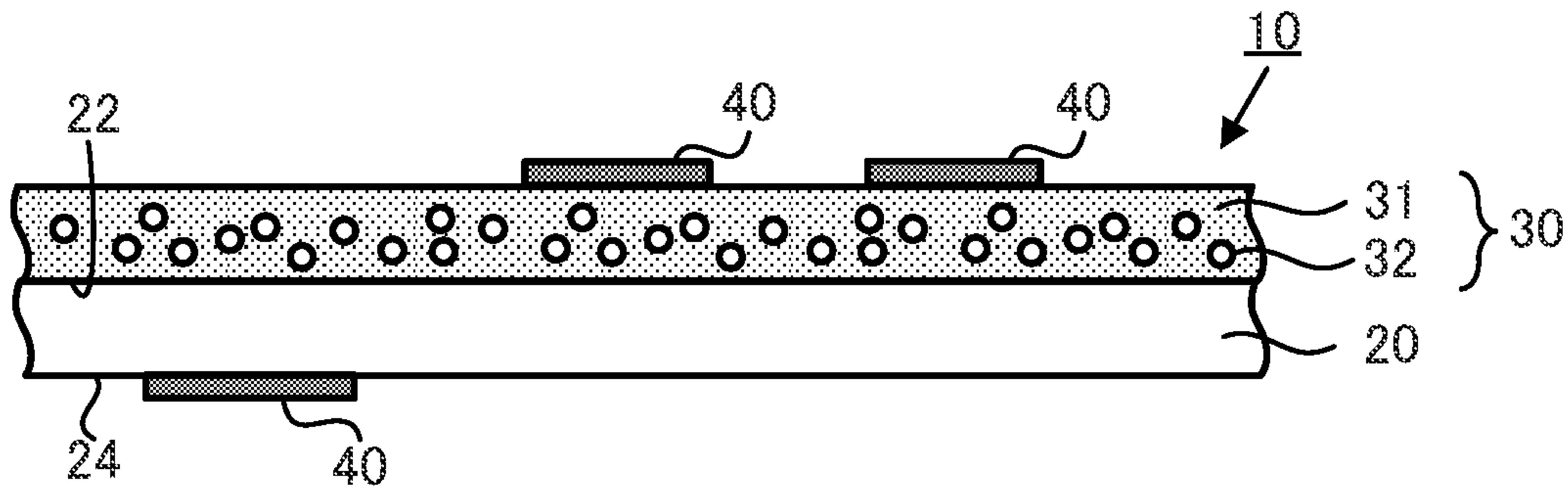


FIG. 3

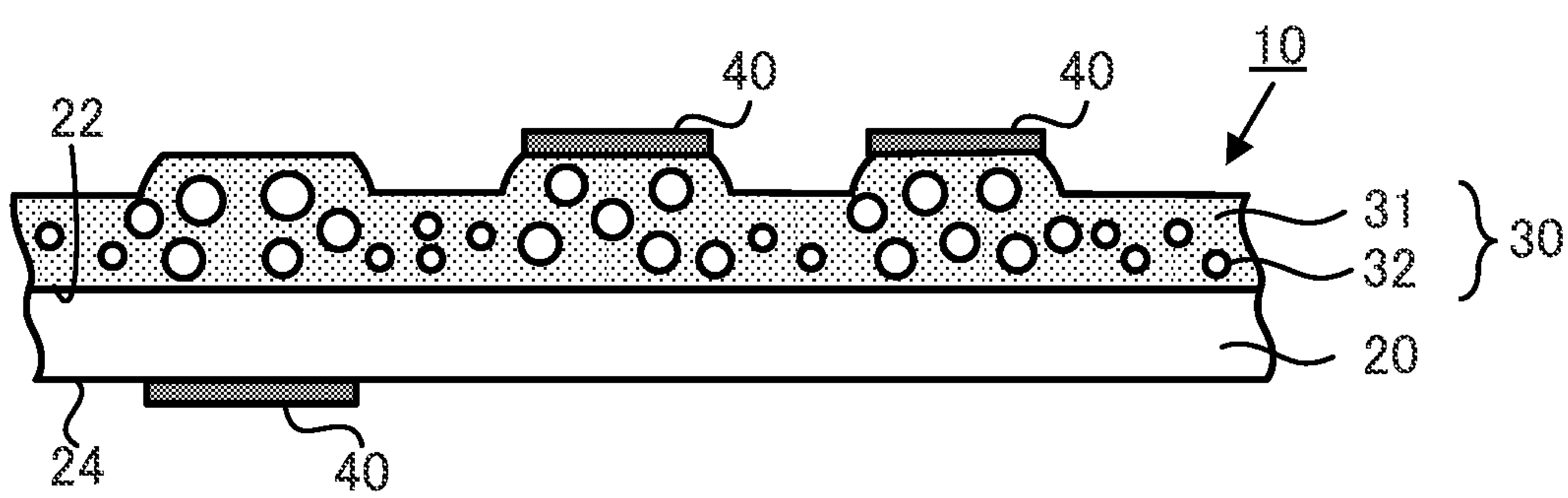


FIG. 4

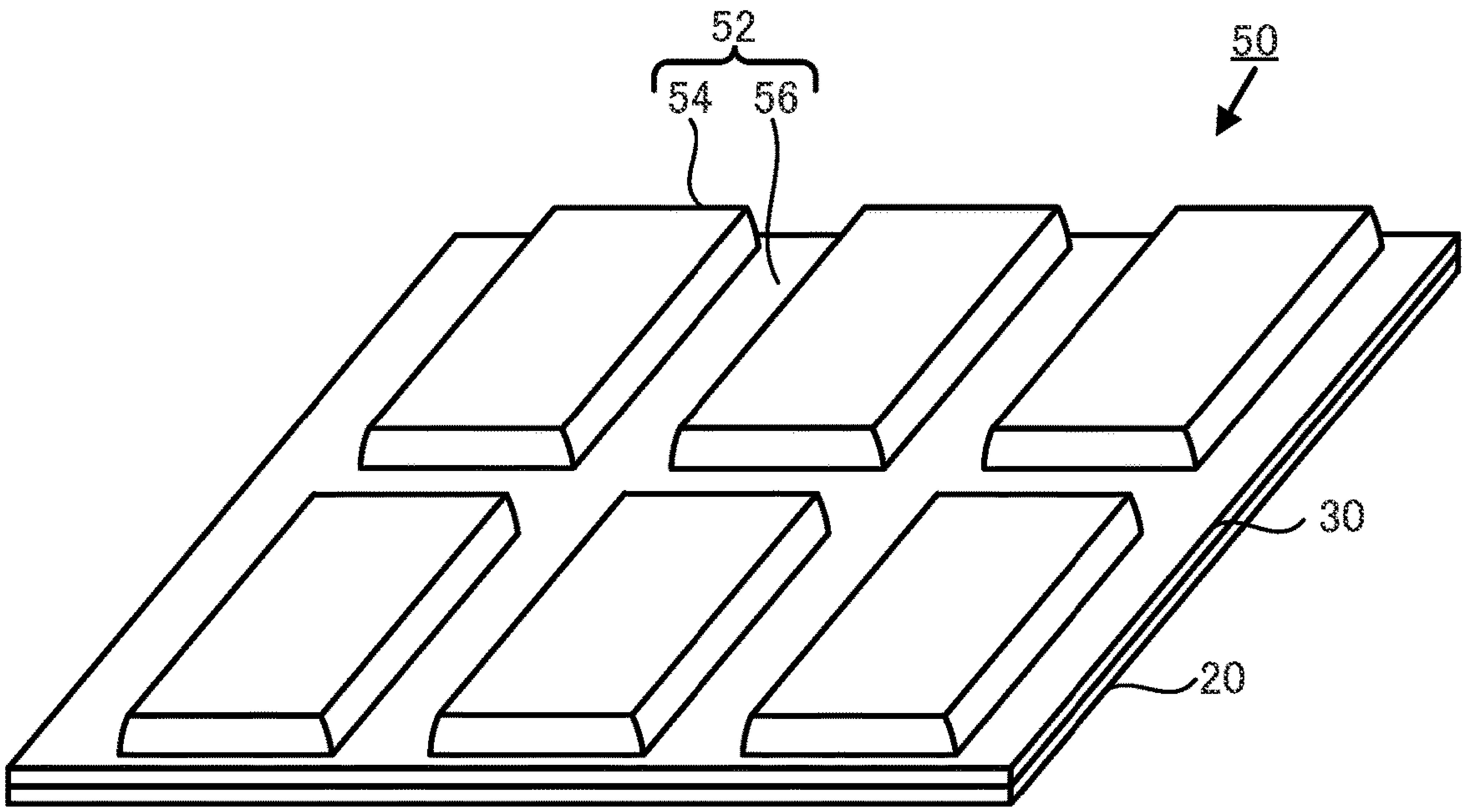

52
54
56
50
30
20

FIG. 5

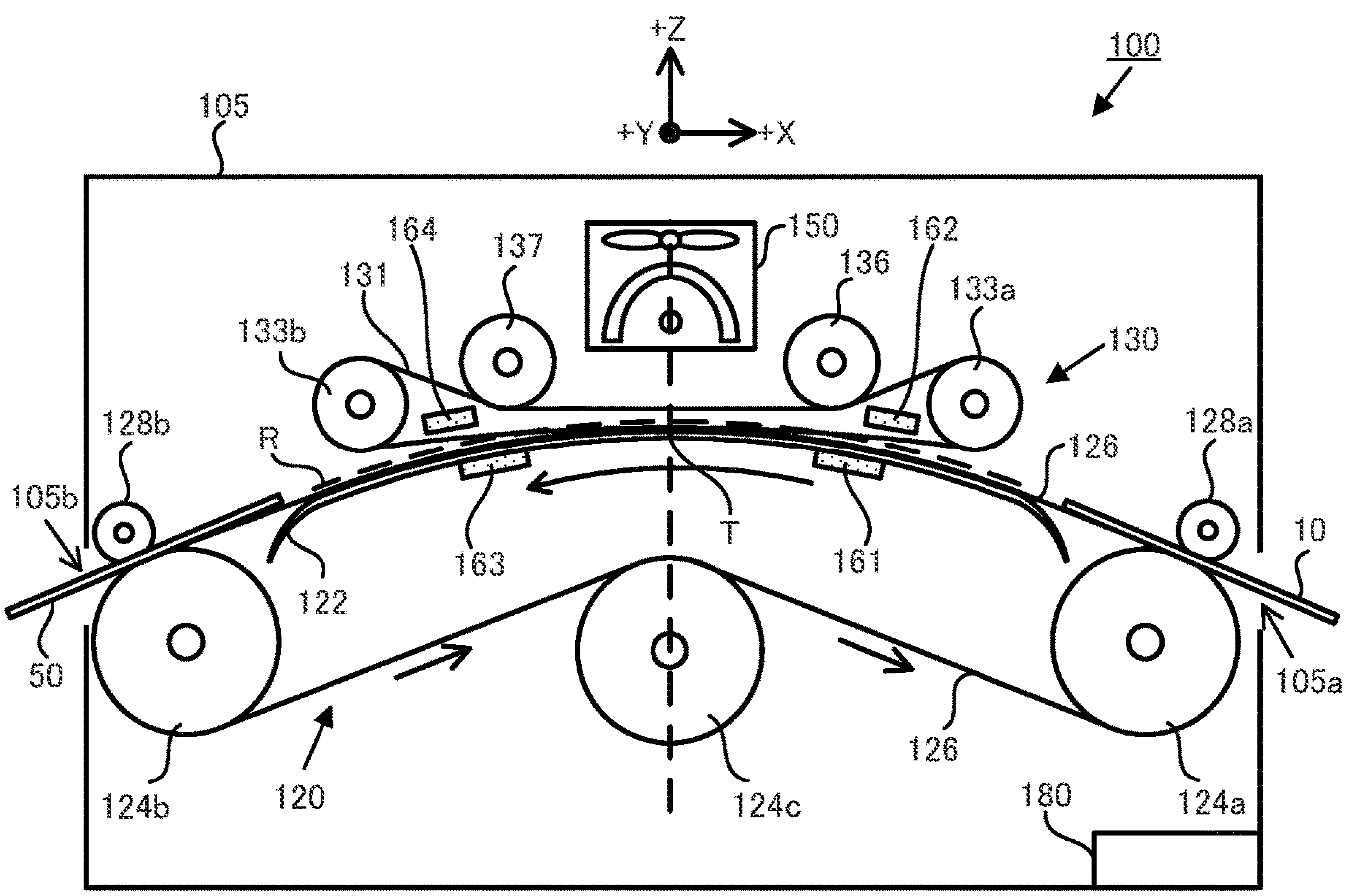

+Z
+Y
+X
100
105
150
164
137
136
162
131
133a
133b
130
128b
128a
R
126
105b
10
122
163
T
161
50
105a
126
124b
120
124c
180
124a

FIG. 6

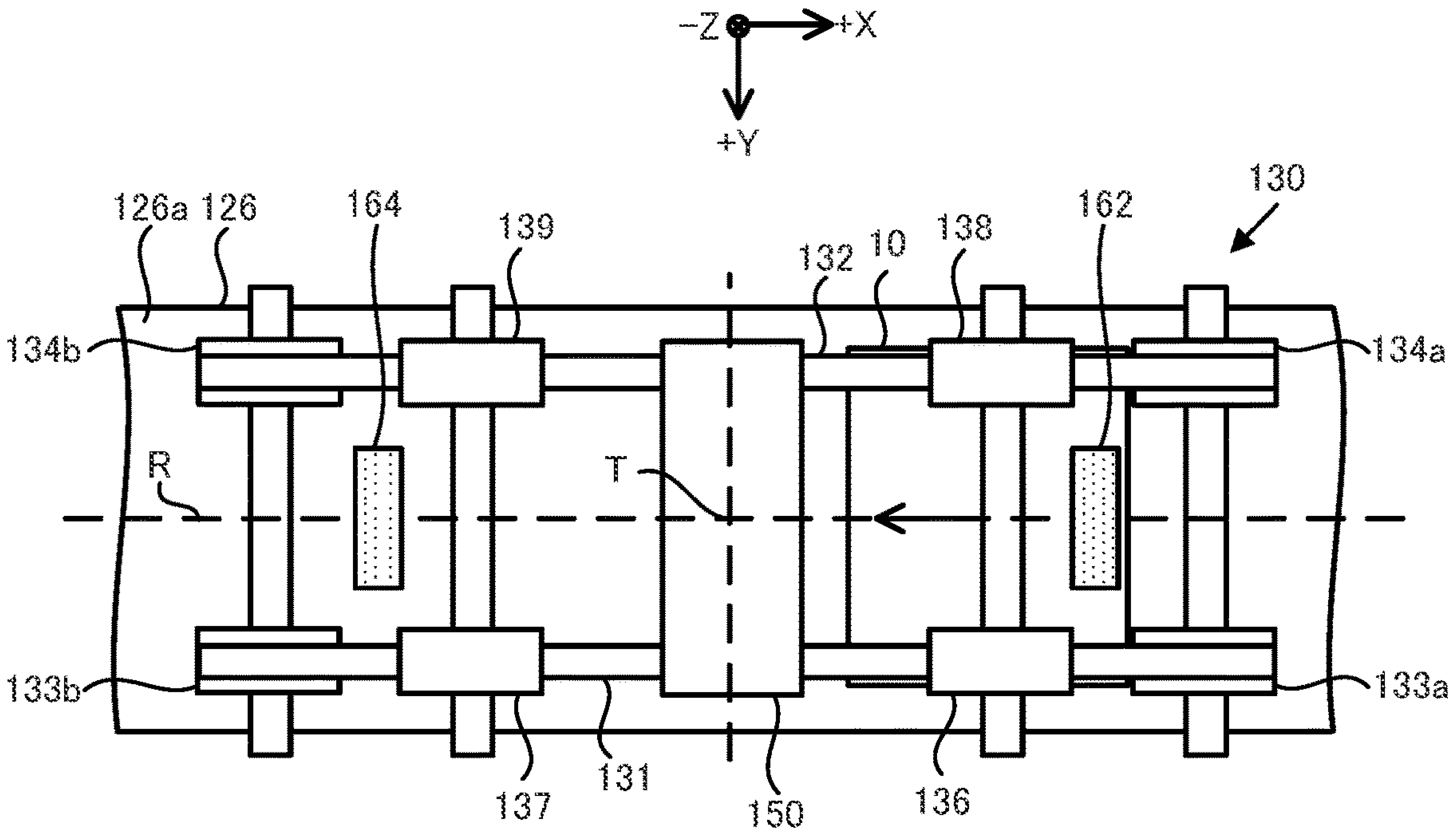

-Z
+X
+Y
130
126a 126
164
139
132
10
138
162
134b
134a
R
T
133b
133a
137
131
150
136

FIG. 7

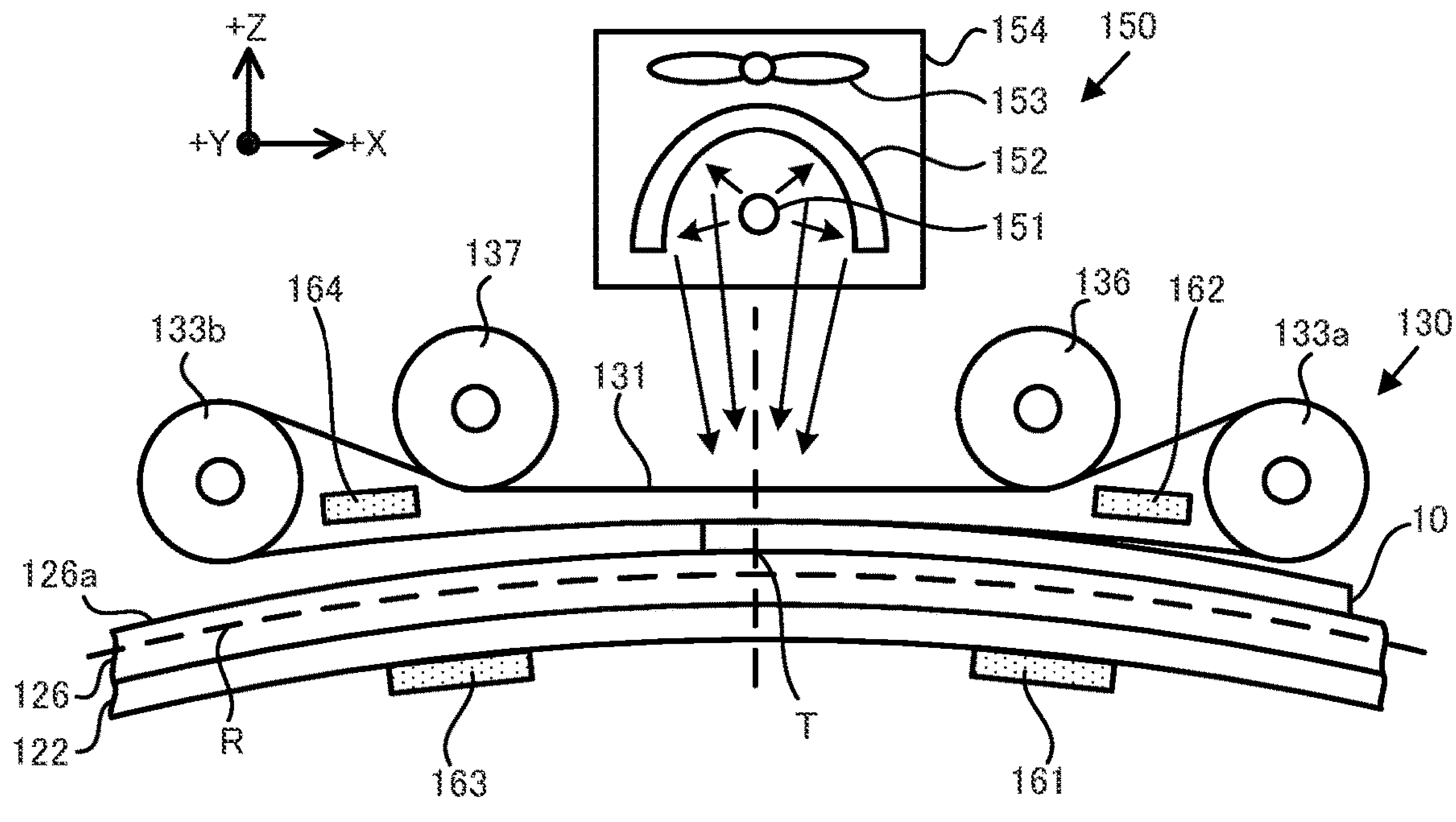

+Z
+Y
+X
154
150
153
152
151
137
136
164
162
133b
133a
130
131
10
126a
126
122
R
T
163
161

FIG. 8

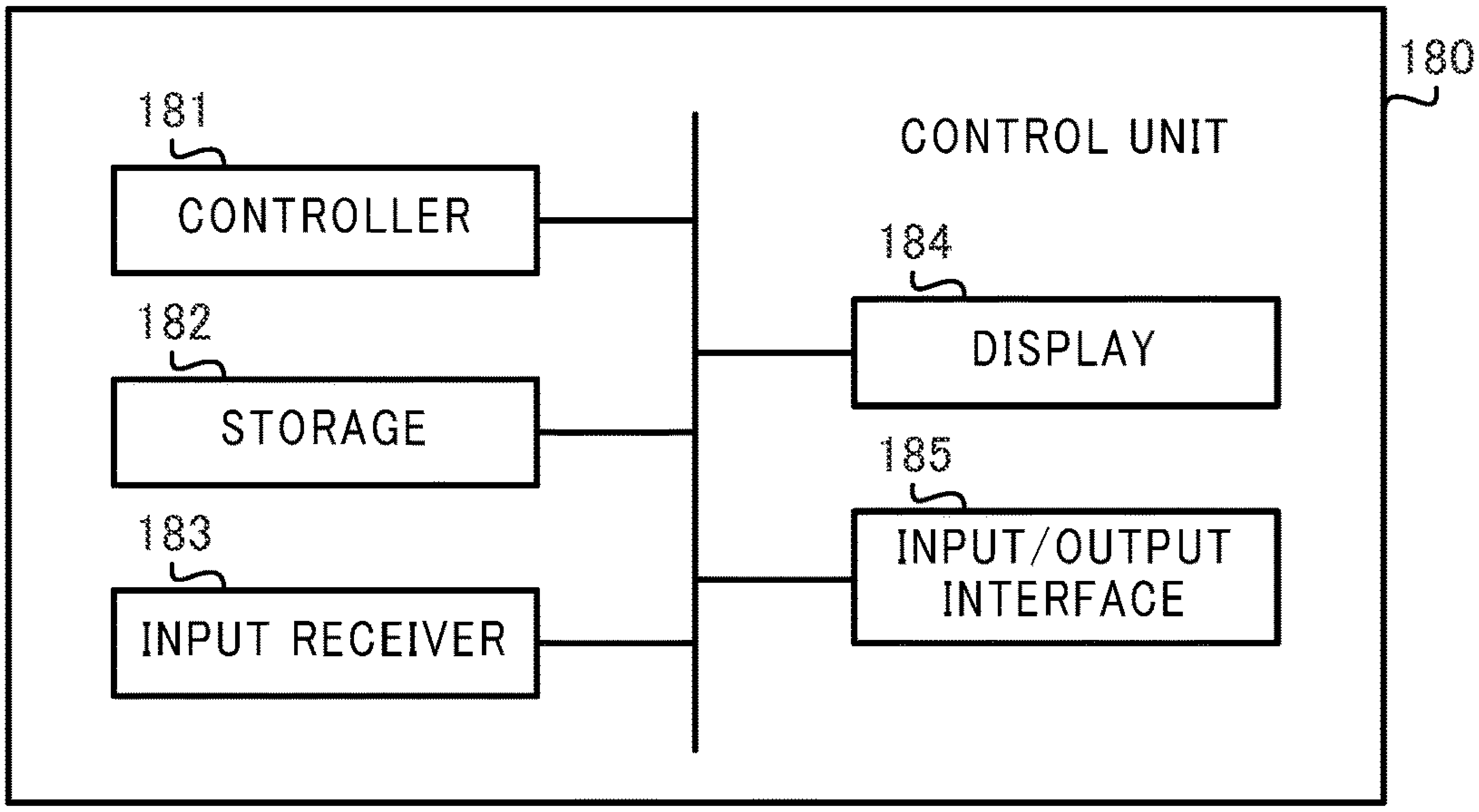

180
CONTROL UNIT
181
CONTROLLER
182
STORAGE
183
INPUT RECEIVER
184
DISPLAY
185
INPUT/OUTPUT INTERFACE

FIG. 9

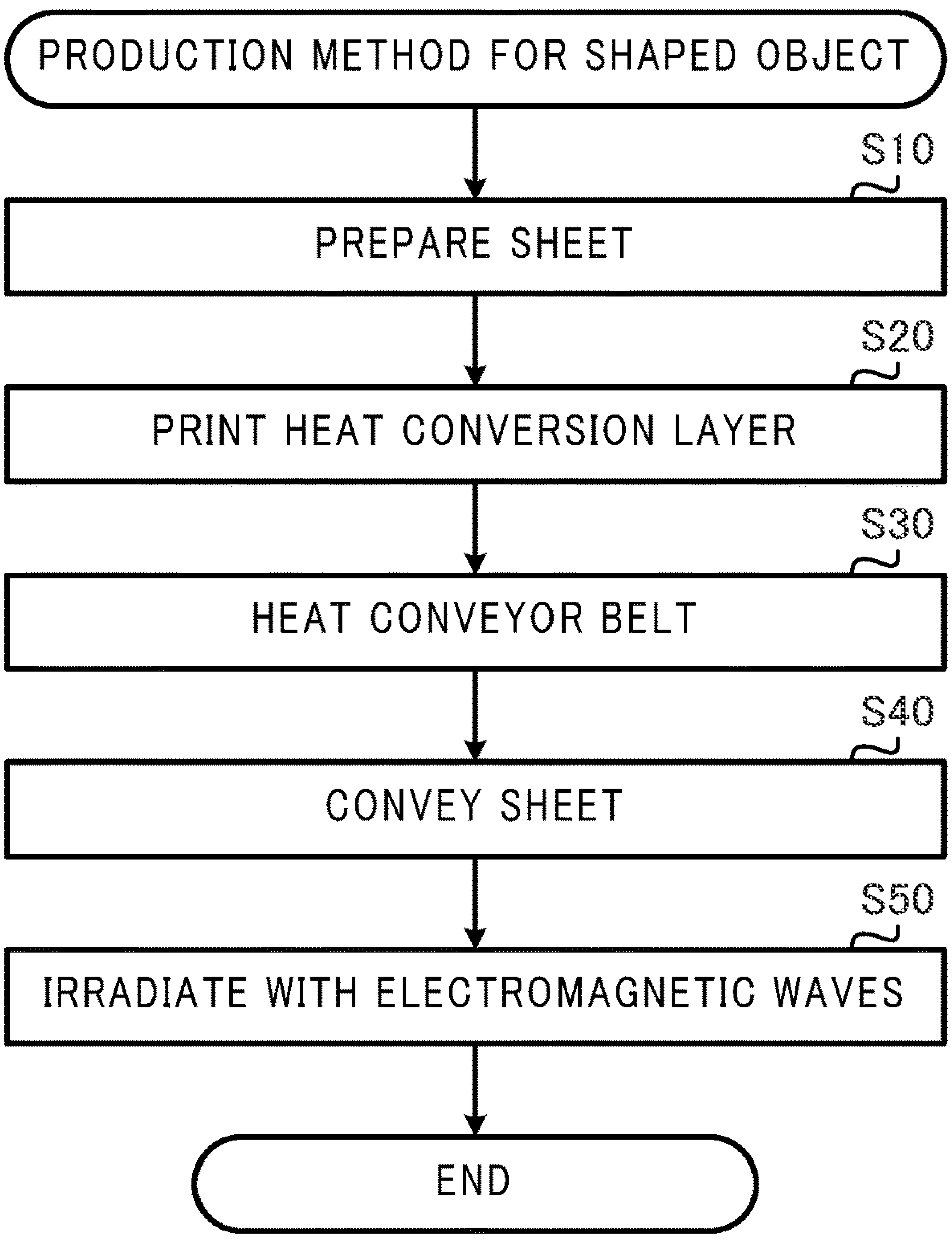

PRODUCTION METHOD FOR SHAPED OBJECT
S10
PREPARE SHEET
S20
PRINT HEAT CONVERSION LAYER
S30
HEAT CONVEYOR BELT
S40
CONVEY SHEET
S50
IRRADIATE WITH ELECTROMAGNETIC WAVES
END

FIG. 10

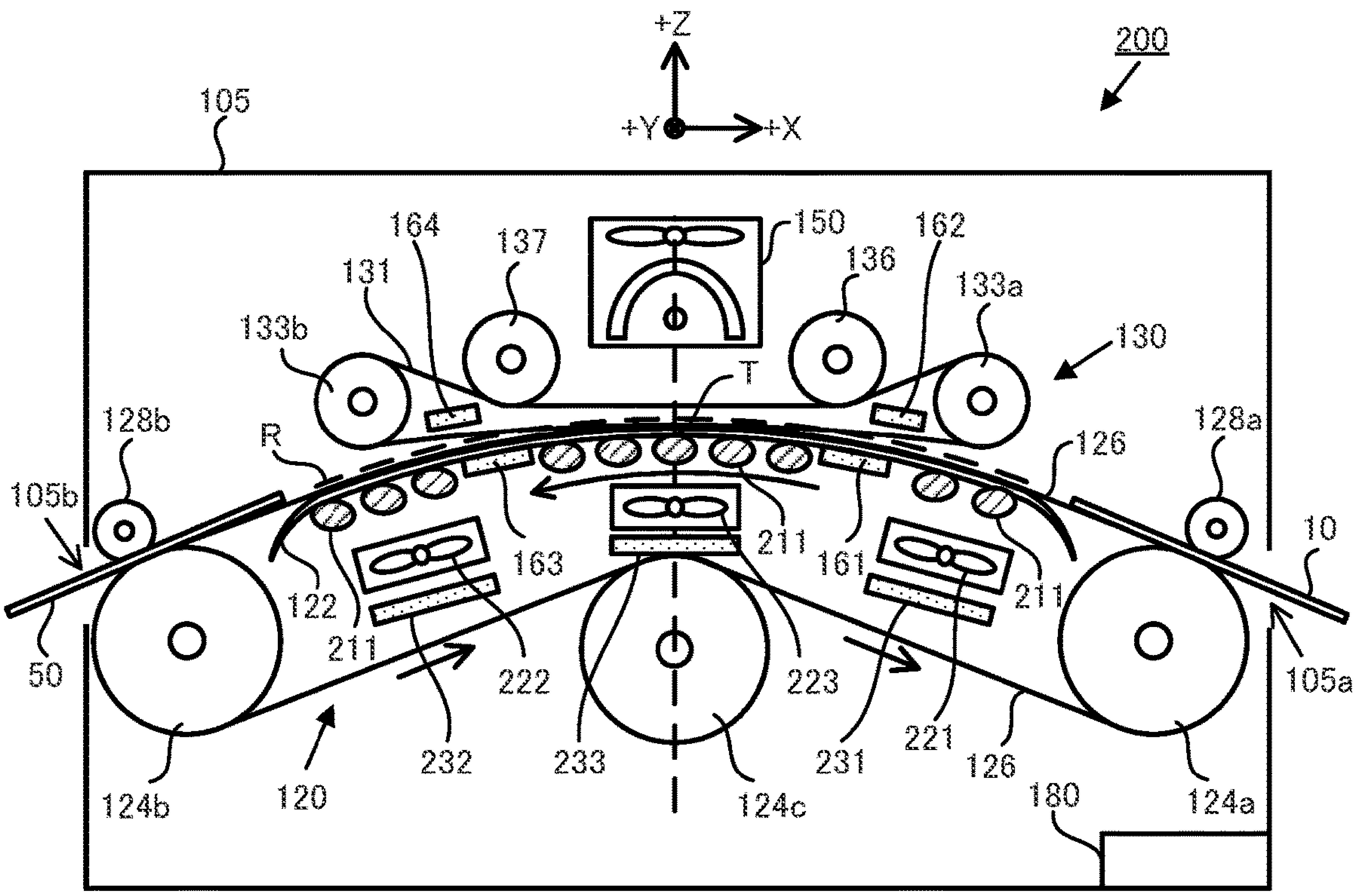

+Z
+Y
+X
200
105
164
137
150
162
136
133a
131
133b
130
T
128b
R
126
128a
105b
10
163
211
161
211
122
211
222
223
221
105a
50
232
233
231
221
126
124b
120
124c
180
124a

FIG. 11

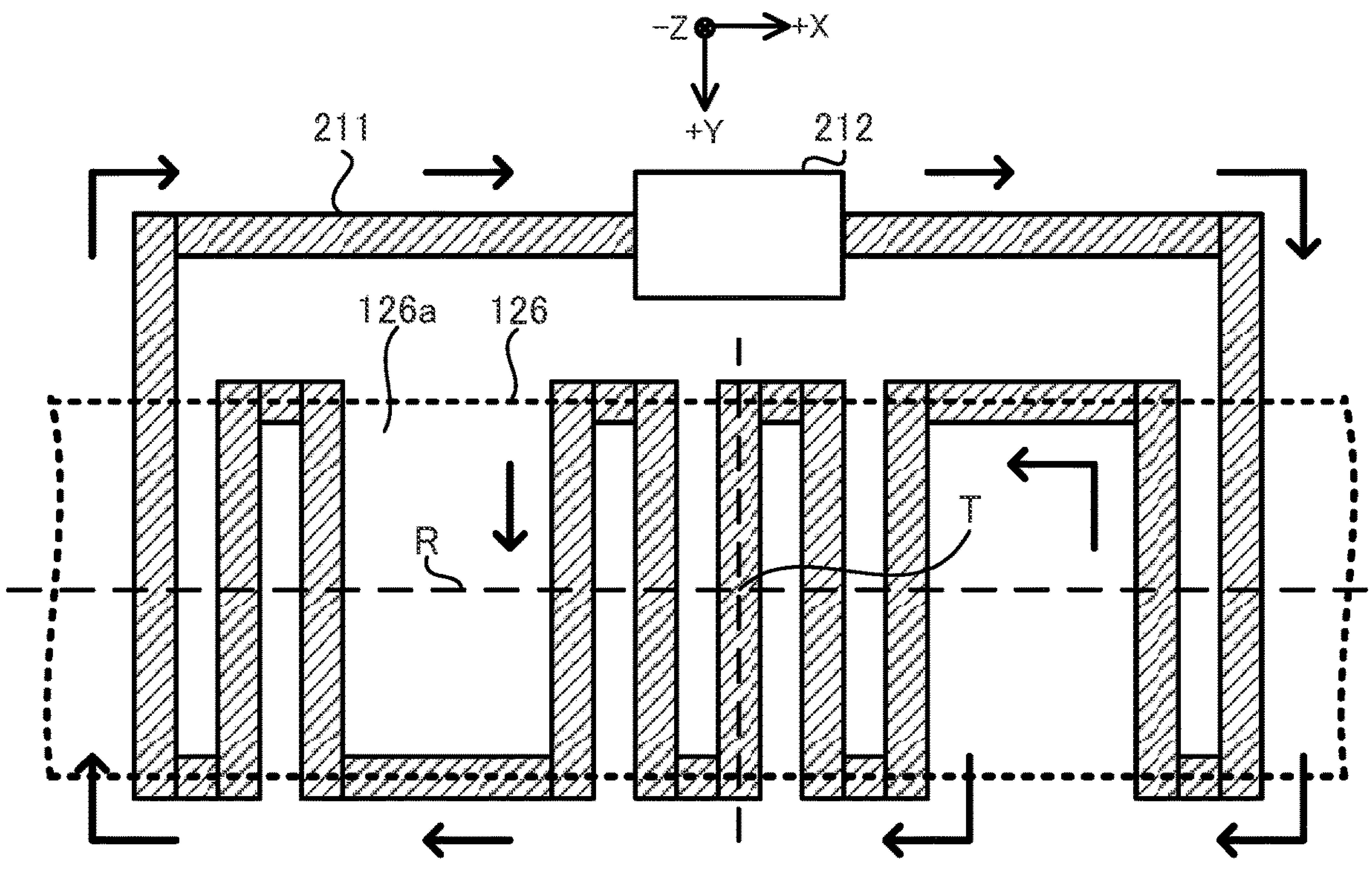

-Z
+X
+Y
211
212
126a
126
R
T

FIG. 12

TEMPERATURE ADJUSTMENT TABLE

TEMPERATURE OF CONVEYOR BELT	WATER TEMPERATURE INSIDE PIPING
70 ℃	40 ℃
65 ℃	45 ℃
60 ℃	50 ℃
55 ℃	55 ℃
50 ℃	60 ℃
45 ℃	65 ℃
40 ℃	70 ℃

COOL

REFERENCE TEMPERATURE

HEAT

FIG. 13

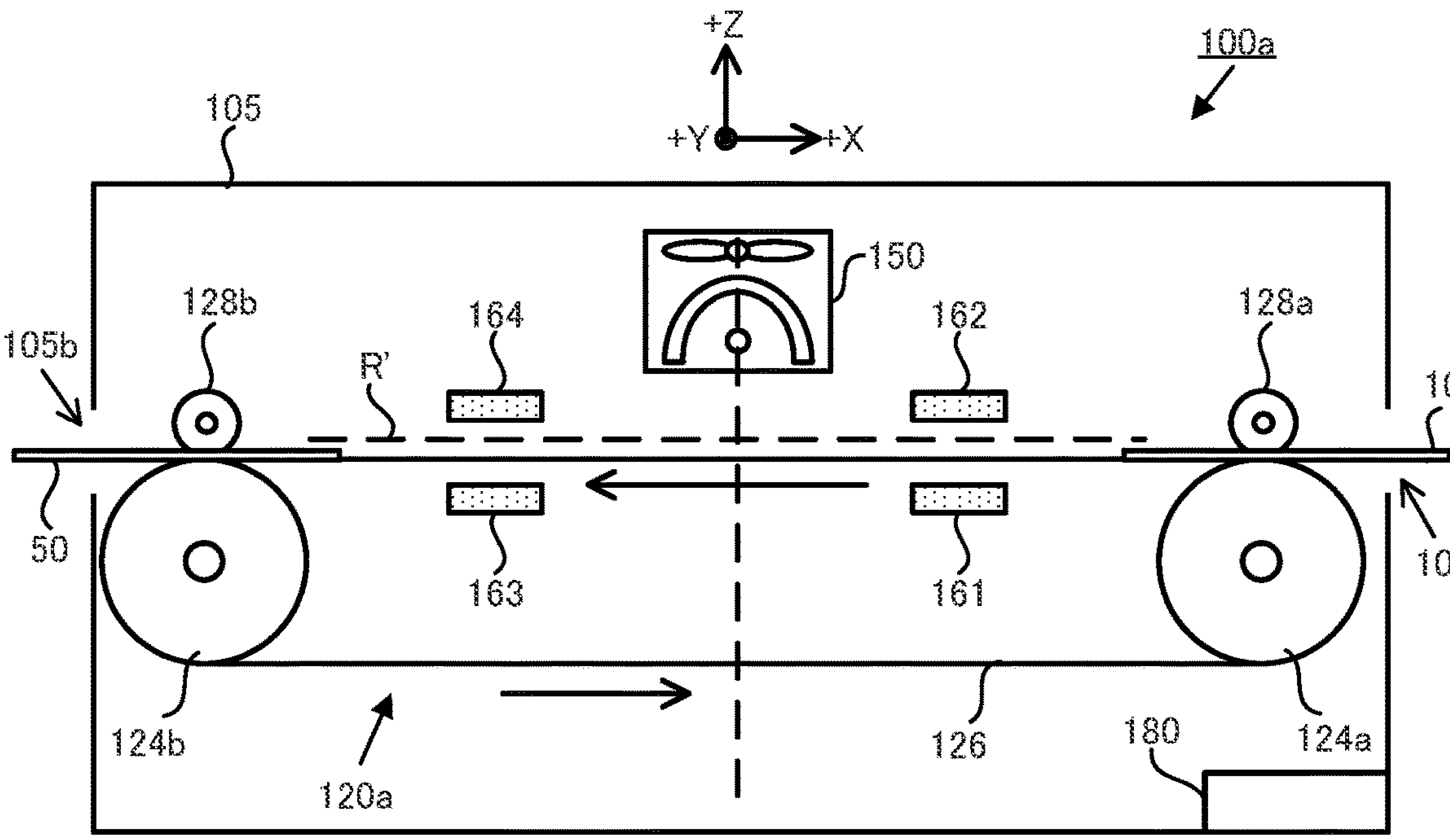
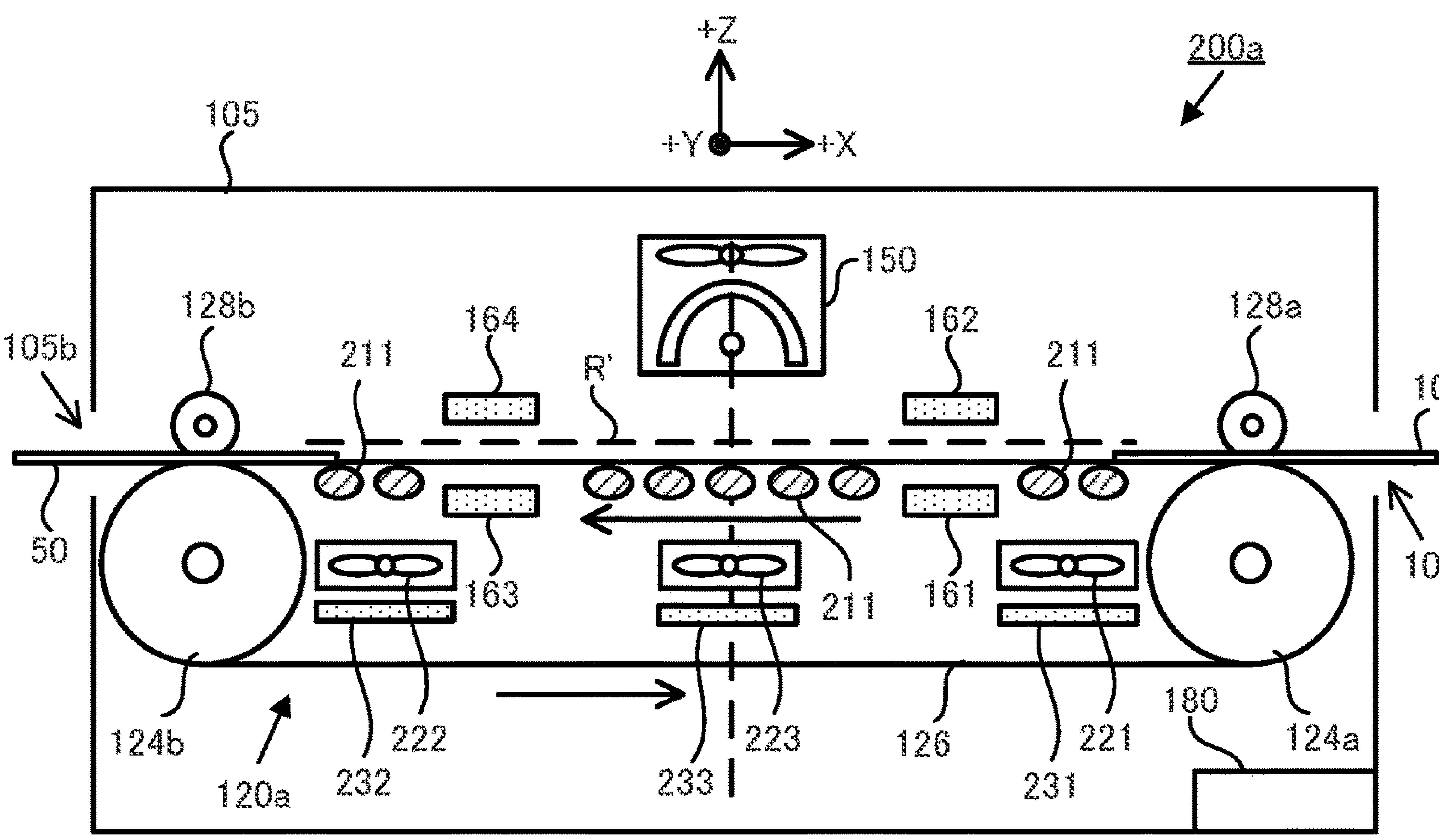

+Z
+Y
+X
100a
105
150
128b
164
162
128a
105b
R'
10
50
163
161
105a
124b
126
180
124a
120a

FIG. 14


+Z
+Y
+X
200a
105
150
128b
164
162
128a
105b
211
R'
211
10
50
163
211
161
105a
124b
232
222
233
223
126
231
221
180
124a
120a

SHAPING DEVICE AND PRODUCTION METHOD FOR SHAPED OBJECT

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Japanese Patent Application No. 2020-052286, filed on Mar. 24, 2020, and Japanese Patent Application No. 2020-207002, filed on Dec. 14, 2020, of which the entirety of the disclosures is incorporated by reference herein.

FIELD

The present disclosure relates generally to a shaping device and a production method for a shaped object.

BACKGROUND

In the related art, techniques are known for producing a shaped object using a medium that distends as a result of being irradiated with electromagnetic waves. For example, Japanese Unexamined Patent Application Publication No. 2013-178353 discloses an image forming device that forms, as a shaped object, a three-dimensional image by irradiating light on a medium that includes a thermally expansive layer containing a thermally expandable material that expands due to heat. More specifically, the image forming device disclosed in Japanese Unexamined Patent Application No. 2013-178353 forms, on a medium, a developer image using a developer that contains a light absorbing material, and irradiates the medium on which the developer image is formed with light having a wavelength that the developer can absorb.

SUMMARY

A shaping device according to the present disclosure that achieves the objective described above includes:

- a conveyor belt on which a sheet is placed, the sheet distending due to being irradiated with electromagnetic waves;
- an irradiator that irradiates the electromagnetic waves on the sheet placed on the conveyor belt; and
- at least one heater that heats the conveyor belt.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of this application can be obtained when the following detailed description is considered in conjunction with the following drawings, in which:

FIG. **1** is a cross-sectional view of a sheet according to Embodiment 1 of the present disclosure;

FIG. **2** is a drawing illustrating an example in which a heat conversion layer is formed on the sheet depicted in FIG. **1**;

FIG. **3** is a drawing illustrating an example in which the sheet depicted in FIG. **2** is distended;

FIG. **4** is a perspective view illustrating an example of a shaped object according to Embodiment 1;

FIG. **5** is a schematic drawing illustrating a shaping device according to Embodiment 1;

FIG. **6** is a top view illustrating a tensioner of the shaping device depicted in FIG. **5**;

FIG. **7** is a schematic drawing illustrating, in an enlarged manner, the tensioner, an irradiator, and a heating unit of the shaping device depicted in FIG. **5**;

FIG. **8** is a block diagram illustrating the configuration of a control unit of the shaping device depicted in FIG. **5**;

FIG. **9** is a flowchart illustrating the flow of production processing of the shaped object according to Embodiment 1;

FIG. **10** is a schematic drawing illustrating a shaping device according to Embodiment 2 of the present disclosure;

FIG. **11** is a top view illustrating an installation example of piping in the shaping device according to Embodiment 2;

FIG. **12** is a drawing illustrating an example of a temperature adjustment table of Embodiment 2;

FIG. **13** is a schematic drawing illustrating a shaping device according to a modified example of Embodiment 1; and

FIG. **14** is a schematic drawing illustrating a shaping device according to a modified example of Embodiment 2.

DETAILED DESCRIPTION

Hereinafter, embodiments of the present disclosure are described while referencing the drawings. Note that, in the drawings, identical or corresponding components are denoted with the same reference numerals.

Embodiment 1

Sheet **10**

FIG. **1** illustrates a cross-section of the structure of a sheet **10** (formable sheet) according to Embodiment 1 of the present disclosure. The sheet **10** is for producing a shaped object. The sheet **10** is a medium in which a pre-selected portion is heated and thereby distended to shape a shaped object. The sheet **10** is also called a thermally expandable sheet.

The shaped object is an object having a three-dimensional shape and is shaped in the two-dimensional sheet as a result of a portion of the sheet distending in a direction outward from a front surface of the sheet. The shaped object is also referred to as a three-dimensional object or a three-dimensional image. The shaped object may have a general shape such as a simple shape, a geometrical shape, or a character.

More specifically, the shaped object of the present embodiment uses, as a reference, a particular two-dimensional plane within three-dimensional space, and includes unevenness in a direction perpendicular or in a direction diagonal to that two-dimensional plane. This shaped object is included in a three-dimensional (3-dimensional) images, but to distinguish this shaped object from a three-dimensional image produced using a so-called 3D printing technique, the shaped object is called a 2.5-dimensional (2.5D) image or a pseudo-three-dimensional (pseudo-3D) image. Furthermore, the technique for producing the shaped object is included in three-dimensional image printing techniques, but to distinguish this technique from a so-called 3D printer, the technique is called a 2.5-dimensional printing technique or a pseudo-three-dimensional printing technique. The expression of aesthetics or texture through visual or tactile sensation by shaping (molding) is referred to as "decorating (ornamenting)."

As illustrated in FIG. **1**, the sheet **10** includes a base **20** and a thermally expansive layer **30**. Note that FIG. **1** illustrates a cross-section of the sheet **10** in a state prior to the shaped object being produced or, in other words, in a state in which no portions of the sheet **10** are distended. In the following, the side of the thermally expansive layer **30** is called the front side of the sheet **10**, and the side of the base **20** is called the back side of the sheet **10**.

The base **20** is a sheet-like medium that serves as the foundation of the sheet **10**.

The base **20** is a support body that supports the thermally expansive layer **30**, and is responsible for maintaining the strength of the sheet **10**. Common printer paper, for example, can be used as the base **20**. However, the material of the base **20** is not particularly limited and examples thereof include synthetic paper, canvas and similar fabrics, and plastic films such as polypropylene, polyethylene terephthalate (PET), and polybutylene terephthalate (PBT). The base **20** of the sheet **10** includes a first main surface **22**, and a second main surface **24** on a side opposite the first main surface **22**.

The thermally expansive layer **30** is laminated on the first main surface **22** of the base **20**, and expands as a result of being heated to a predetermined expansion temperature or higher. The thermally expansive layer **30** includes a binder **31** and a thermally expansive material **32** dispersed in the binder **31**. The binder **31** is a thermoplastic resin such as ethylene-vinylacetate polymer or acrylic polymer. Specifically, the thermally expansive material **32** comprises thermally expandable microcapsules (micropowder) having a particle size of about 5 to 50 μm. These microcapsules are formed by encapsulating, in a thermoplastic resin shell, a substance that vaporizes at a low boiling point such as propane or butane. When the thermally expansive material **32** is heated to a temperature of about 80° C. to 120° C., for example, the encapsulated substance vaporizes, and the resulting pressure causes the thermally expandable agent to foam and expand. Thus, the thermally expansive layer **30** expands according to the amount of heat absorbed. The thermally expansive material **32** is also called a foaming agent.

A heat conversion layer **40** that converts electromagnetic waves to heat is formed on portions of the surface of the front side or the back side of the sheet **10** to be caused to distend. FIG. **2** illustrates, as an example, a state in which the heat conversion layer **40** is formed in a portion of each of the surface of the front side (specifically, the front surface of the thermally expansive layer **30**) and the surface of the back side (specifically, the second main surface **24** of the base **20**) of the sheet **10**. The heat conversion layer **40** is formed by printing on the surface of the front side or the back side of the sheet **10** using a printing device such as an ink jet printer or the like.

The heat conversion layer **40** converts electromagnetic waves to heat and radiates the converted heat. As a result, the thermally expansive material **32** in the thermally expansive layer **30** is heated to a predetermined temperature. The temperature to which the thermally expansive material **32** is heated can be controlled by the density of the heat conversion layer **40** formed on the surface of the front side or the back side of the sheet **10**, and by the amount of energy per unit area and per unit time of the electromagnetic waves irradiated on the heat conversion layer **40**. The heat conversion layer **40** converts the electromagnetic waves to heat faster than the other portions of the sheet **10**. As such, the regions near the heat conversion layer **40** (the thermally expansive layer **30**) are selectively heated.

Examples of the material of the heat conversion layer **40** include carbon black, metal hexaboride compounds, and tungsten oxide compounds. Carbon black, for example, absorbs and converts visible light, infrared light, and the like to heat. Metal hexaboride compounds and tungsten oxide compounds absorb and convert near-infrared light to heat.

Among the metal hexaboride compounds and the tungsten oxide compounds, lanthanum hexaboride (LaB6) and cesium tungsten oxide are preferable from the perspectives of obtaining high light absorptivity in the near-infrared region and high transmittance in the visible light spectrum.

When the thermally expansive layer **30** is heated to the predetermined expansion temperature due to the heat conversion layer **40** converting the electromagnetic waves to heat, the thermally expansive material **32**, of the thermally expansive material **32** included in the thermally expansive layer **30**, existing at positions corresponding to the regions in which the heat conversion layer **40** is formed expands. As a result, as illustrated in FIG. **3**, the portions of sheet **10** where the heat conversion layer **40** is formed rise toward the front side, and bumps are formed. A protruding or uneven shape is formed by the bumps of the thermally expansive layer **30** and, as a result, a shaped object **50** such as illustrated in FIG. **4**, for example, is produced.

Shaped Object **50**

The shaped object **50** is a sheet-like shaped object, and includes unevennesses **52**, specifically a protrusion **54** and a recess **56**, on the front surface. The shaped object **50** is used as a decorative sheet, wallpaper, or the like, for example.

As illustrated in FIG. **4**, the shaped object **50** includes the base **20**, the thermally expansive layer **30** that is laminated on the first main surface **22** of the base **20** and that includes the unevennesses **52** on the side opposite the base **20**, and the heat conversion layer **40** that is formed in a pattern corresponding to the unevennesses **52** on the surface of the front side or the back side of the base **20**. A variety of shaped objects, including the shaped object **50**, can be produced by combining regions in which and distension heights to which the sheet **10** is caused to distend.

Shaping Device **100**

Next, the shaping device **100** is described. The shaping device **100** produces a shaped object **50** such as that illustrated in FIG. **4**, for example, by irradiating the sheet **10** with electromagnetic waves to cause the sheet **10** to distend. When the sheet **10** is to be irradiated with the electromagnetic waves in the shaping device **100**, the sheet **10** includes the base **20**, the thermally expansive layer **30**, and the heat conversion layer **40**, as illustrated in FIG. **2**.

As illustrated in FIG. **5**, the shaping device **100** includes a conveyor **120**, a tensioner **130**, an irradiator **150**, and a control unit **180**. These constituents are provided within a housing **105**. The housing **105** includes a loading port **105***a* through which the sheet **10** is loaded, and a discharge port **105***b* through which the produced shaped object **50** is discharged.

Note that, to facilitate comprehension, in the shaping device **100** of FIG. **5**, the longitudinal right direction (the right direction on paper) is referred to as the "+X direction", the up direction (the up direction on paper) is referred to as the "+Z direction", and the direction perpendicular to the +X direction and the +Z direction (the front direction on paper) is referred to as the "+Y direction."

Conveyor **120**

The conveyor **120** conveys the sheet **10**, loaded through the loading port **105***a* of the housing **105**, along a conveyance route R. The conveyance route R is a route leading from the loading port **105***a* to the discharge port **105***b* of the housing **105**. The conveyance route R is a convexly curved route, and curves so as to protrude in the +Z direction. A position of the conveyance route R irradiated with the electromagnetic waves by the irradiator **150** is a peak T of the conveyance route R.

More specifically, the conveyor **120** includes a guide **122**, a driven roller **124***a*, a driving roller **124***b*, a tension roller **124***c*, a conveyor belt **126**, a loading roller **128***a*, and a discharge roller **128***b*.

The guide **122** is disposed between an outgoing portion and a return portion of the conveyor belt **126**. Similar to the conveyance route R, the guide **122** has a shape that curves so as to protrude in the +Z direction. The guide **122** supports the outgoing portion of the conveyor belt **126** from the −Z side while curving along the convexly curved conveyance route R. Additionally, the guide **122** conducts heat with the conveyor belt **126**.

The driven roller **124***a* is disposed on the loading port **105***a* side (the +X side) of the housing **105**, and the conveyor belt **126** is wound on the driven roller **124***a*. The rotational axis of the driven roller **124***a* is disposed in a direction (Y direction) orthogonal to the conveyance direction (the −X direction) of the sheet **10** and the protruding direction (the +Z direction) of the conveyance route R. The driven roller **124***a* is axially supported by side plates of the housing **105**.

The driving roller **124***b* is disposed on the discharge port **105***b* side (the −X side) of the housing **105**, and the conveyor belt **126** is wound on the driving roller **124***b*. The rotational axis of the driving roller **124***b* is disposed in the Y direction, similar to the rotational axis of the driven roller **124***a*. The driving roller **124***b* is axially supported by the side plates of the housing **105**. The driving roller **124***b* rotates counter-clockwise when viewed from the +Y direction due the rotation of a non-illustrated motor, thereby causing the conveyor belt **126** to run.

The tension roller **124***c* is disposed below (on the −Z side of) the return portion of the conveyor belt **126**. The tension roller **124***c* presses on the return portion of the conveyor belt **126** from the −Z side to apply tension to the conveyor belt **126**. The rotational axis of the tension roller **124***c* is disposed in the Y direction, similar to the rotational axis of the driven roller **124***a*. The tension roller **124***c* is axially supported by the side plates of the housing **105**.

The conveyor belt **126** is an endless belt that is wound on the driven roller **124***a* and the driving roller **124***b*. The outgoing portion of the conveyor belt **126** is supported by the guide **122** and, as such, convexly curves along the convexly curved conveyance route R. The conveyor belt **126** runs due to the rotation of the driving roller **124***b*. Specifically, the outgoing portion of the conveyor belt **126** runs along the conveyance route R in the −X direction, and the return portion of the conveyor belt **126** runs in the +X direction.

The conveyor belt **126** includes a conveyance surface **126***a*. The sheet **10** is placed on the conveyance surface **126***a* and conveyed. Specifically, in a case in which the heat conversion layer **40** is formed on the surface of the front side of the sheet **10**, the sheet **10** is placed on the conveyor belt **126** such that the surface of the back side of the sheet **10** faces the conveyance surface **126***a* of the conveyor belt **126**, and the surface of the front side of the sheet **10** faces upward. Meanwhile, in a case in which the heat conversion layer **40** is formed on the surface of the back side of the sheet **10**, the sheet **10** is placed on the conveyor belt **126** such that the surface of the front side of the sheet **10** faces the conveyance surface **126***a* of the conveyor belt **126**, and the surface of the back side of the sheet **10** faces upward.

The conveyor belt **126** runs due to the rotation of the driving roller **124***b*, thereby conveying the sheet **10** placed on the conveyor belt **126** in the −X direction along the conveyance route R from the loading port **105***a* of the housing **105**. Moreover, the conveyor belt **126** conveys the shaped object **50**, produced by the sheet **10** being irradiated with the electromagnetic waves by the irradiator **150**, to the discharge port **105***b* of the housing **105**.

Thus, the conveyor belt **126** spans from the loading port **105***a* side (the +X side) to the discharge port **105***b* side (the −X side) with respect to the irradiation position of the electromagnetic waves by the irradiator **150**. Due to this configuration, the conveyor belt **126** conveys the sheet **10** from the loading port **105***a* to the irradiation position of the electromagnetic waves by the irradiator **150**, and conveys the shaped object **50** produced by the irradiation of the electromagnetic waves to the discharge port **105***b*.

Similar to the driven roller **124***a*, the loading roller **128***a* is axially supported by the side plates of the housing **105**. The sheet **10** inserted through the loading port **105***a* is sandwiched between the loading roller **128***a* and the conveyor belt **126**, and the sheet **10** is loaded into the housing **105**.

Similar to the driving roller **124***b*, the discharge roller **128***b* is axially supported by the side plates of the housing **105**. The shaped object **50** produced from the sheet **10** is sandwiched between the discharge roller **128***b* and the conveyor belt **126**, and is discharged through the discharge port **105***b*.

Tensioner **130**

The tensioner **130** applies tension along the convexly curved conveyance route R to the sheet **10** being conveyed by the conveyor **120**. As illustrated in FIG. **6**, the tensioner **130** includes a pair of presser belts **131**, **132**. Each of the presser belts **131**, **132** applies tension along the conveyance route R to the sheet **10** by pressing each end of the sheet **10** in the width direction of the conveyor belt **126** (the +Y direction end and the −Y direction end) against the conveyor belt **126**.

More specifically, the tensioner **130** includes a first pulley **133***a* and a second pulley **133***b* on which the presser belt **131** is wound, and a third pulley **134***a* and a fourth pulley **134***b* on which the presser belt **132** is wound. Additionally, the tensioner **130** includes two bend pulleys **136**, **137** that change the running direction of the presser belt **131**, and two bend pulleys **138**, **139** that change the running direction of the presser belt **132**.

The first pulley **133***a* and the second pulley **133***b* are respectively disposed on the +X side and the −X side of the peak T of the conveyor belt **126**. A lower end of an outer periphery of the first pulley **133***a* and a lower end of an outer periphery of the second pulley **133***b* are positioned more to the −Z side than the peak T of the outgoing portion of the conveyor belt **126**. Accordingly, the outgoing portion of the presser belt **131** presses the +Y side end of the sheet **10** being conveyed by the conveyor belt **126** against the conveyor belt **126**.

The third pulley **134***a* and the fourth pulley **134***b* are respectively disposed on the +X side and the −X side of the peak T of the conveyor belt **126**. A lower end of an outer periphery of the third pulley **134***a* and a lower end of an outer periphery of the fourth pulley **134***b* are positioned more to the −Z side than the peak T of the outgoing portion of the conveyor belt **126**. Accordingly, the outgoing portion of the presser belt **132** presses the −Y side end of the sheet **10** being conveyed by the conveyor belt **126** against the conveyor belt **126**.

Thus, the presser belts **131**, **132** respectively press the +Y side end and the −Y side end of the sheet **10** against the conveyor belt **126**. As such, tension along the conveyance route R is applied to the +Y side end and the −Y side end of the sheet **10**. As a result, it is possible to suppress warping, bending, and the like of the sheet **10** being conveyed by the conveyor **120**.

Irradiator **150**

The irradiator **150** irradiates the sheet **10**, placed on and being conveyed by the conveyor belt **126**, with the electromagnetic waves. As illustrated in FIG. **5**, the irradiator **150** is disposed above (on the +Z side of) the peak T of the conveyor belt **126**. The irradiator **150** irradiates the electromagnetic waves from above toward the surface of the upper side of the sheet **10** being conveyed by the conveyor belt **126** while tension is applied by the tensioner **130**.

When the sheet **10** on which the heat conversion layer **40** is formed is irradiated with the electromagnetic waves from the irradiator **150**, the heat conversion layer **40** converts the electromagnetic waves to heat and heats the thermally expansive material **32** included in the thermally expansive layer **30** to the predetermined temperature or higher. The heat conversion layer **40** is formed on the surface of the front side or the back side of the sheet **10** in a pattern corresponding to the unevennesses **52** of the shaped object **50**. As such, the portions of the thermally expansive layer **30** corresponding to the protrusion **54** are heated to the predetermined temperature or higher, and the thermally expansive material **32** expands. As a result, the thermally expansive layer **30** expands and the protrusion **54** (that is, the unevennesses **52**) is formed in the thermally expansive layer **30**.

More specifically, as illustrated in FIG. **7**, the irradiator **150** includes a lamp **151**, a reflector **152**, a fan **153**, and a cover **154**.

The lamp **151** emits the electromagnetic waves. In one example, the lamp **151** is a halogen lamp, and emits electromagnetic waves in the near-infrared region (750 to 1400 nm wavelength range), the visible light spectrum (380 to 750 nm wavelength range), or the intermediate infrared region (1400 to 4000 nm wavelength range). The lamp **151** is formed in a straight pipe shape in the width direction (Y direction) of the conveyor belt **126** so as to enable the electromagnetic waves to be irradiated evenly in the width direction (Y direction) on the sheet **10** that is placed on and is being conveyed by the conveyor belt **126**.

The reflector **152** reflects the electromagnetic waves emitted from the lamp **151** toward the sheet **10** that is placed on and is being conveyed by the conveyor belt **126**. The reflector **152** is disposed so as to cover the lamp **151** from above. The reflector **152** reflects the electromagnetic waves emitted upward from the lamp **151** downward. The electromagnetic waves emitted from the lamp **151** and reflected by the reflection surface of the reflector **152** advance on the path indicated by the arrows in FIG. **7**, and are focused on the sheet **10** that is placed on and is being conveyed by the conveyor belt **126**. Thus, the electromagnetic waves emitted from the lamp **151** are reflected by the reflector **152** and, thereby focused and irradiated on the sheet **10**.

The fan **153** sends air into the cover **154** to cool the lamp **151** and the reflector **152**. The cover **154** accommodates the lamp **151**, the reflector **152**, and the fan **153**.

Heating Unit (Heaters **161** to **164**)

As illustrated in FIGS. **5** to **7**, the shaping device **100** further includes four heaters **161** to **164**. In one example, each of the heaters **161** to **164** is a heating wire heater. The heating wire heater includes a nichrome wire as the heating wire and a cover that covers the nichrome wire, and radiates, into the surroundings, heat generated when current flows through the nichrome wire. The heaters **161** to **164** functions as a heating unit that heats the conveyor belt **126**.

The heaters **161** to **164** heat the conveyor belt **126** to a temperature lower than the expansion temperature of the sheet **10**. In this case, the expansion temperature is the temperature at which the thermally expansive material **32** included in the thermally expansive layer **30** begins to expand and, as described above example, is a temperature of about 80° C. to 120° C., for example.

Thus, the heaters **161** to **164** heat the conveyor belt **126** that spans from the upstream side to the downstream side with respect to the irradiation position of the electromagnetic waves by the irradiator **150**. As a result, the temperature environment when the sheet **10** is irradiated with the electromagnetic waves and, thereby is heated and distends can be maintained at constant conditions regardless of whether it is warm or cold, that is, whether the temperature is high or low, around the shaping device **100**. In other words, the heaters **161** to **164** are responsible for heating the conveyor belt **126** to a temperature lower than the expansion temperature to adjust the temperatures of the conveyor belt **126**, and the sheet **10** and the shaped object **50** conveyed by the conveyor belt **126**.

More specifically, the shaping device **100** includes a first heater **161** and a second heater **162** upstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Furthermore, the shaping device **100** includes a third heater **163** and a fourth heater **164** downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**.

In this case, since the conveyor belt **126** conveys the sheet **10** from the loading port **105*a*** side (the +X side) to the discharge port **105*b*** side (the −X side) of the housing **105**, the conveyance direction of the conveyor belt **126** corresponds to from the +X side to the −X side or, rather, the −X direction. That is, upstream from the irradiator **150** in the conveyance direction of the conveyor belt **126** corresponds to farther to the +X side with respect to the position where the irradiator **150** is disposed in the shaping device **100**. Likewise, downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126** corresponds to farther to the −X side with respect to the position where the irradiator **150** is disposed in the shaping device **100**. Hereinafter, each of the four heaters **161** to **164** is described.

The first heater **161** is disposed below the conveyance surface **126*a*** of the conveyor belt **126**, upstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Specifically, the first heater **161** is provided between the outgoing portion and the return portion of the conveyor belt **126**, on the loading port **105*a*** side (the +X side) of the housing **105**.

More specifically, the first heater **161** is attached and fixed to a surface of the lower side of the guide **122** that supports the outgoing portion of the conveyor belt **126** from the lower side (the −Z side). When the first heater **161** emits heat, the guide **122** is heated and that heat transmits to the outgoing portion of the conveyor belt **126**. As a result, the conveyor belt **126** is heated. The material of the guide **122** is preferably a material that has relatively high thermal conductivity such as a metal or an alloy, and is more preferably stainless steel.

The second heater **162** is disposed above the conveyance surface **126*a*** of the conveyor belt **126**, upstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Specifically, as illustrated in FIG. **6**, the second heater **162** is provided between the presser belts **131**, **132** provided on both ends in the width direction (Y direction) of the conveyor belt **126**, on the loading port **105*a*** side (the +X side) of the housing **105**.

More specifically, the second heater **162** is attached to a non-illustrated metal plate, and is fixed at a position spaced upward from the conveyance surface **126*a*** of the conveyor belt **126**. When the second heater **162** emits heat, the conveyor belt **126** is heated by that radiant heat.

Since the first heater **161** and the second heater **162** are provided upstream from the irradiator **150**, the first heater **161** and the second heater **162** apply heat to regions of the conveyor belt **126** that are upstream from the irradiation position of the electromagnetic waves by the irradiator **150**. As such, the sheet **10** is placed on the conveyor belt **126** and is preheated to a temperature lower than the expansion temperature of the thermally expansive layer **30** while being conveyed from the loading port **105***a* to the irradiation position of the electromagnetic waves. Due to this, when irradiating with the electromagnetic waves by the irradiator **150**, the time required for the temperature of the sheet **10** to reach the predetermined expansion temperature or higher can be shortened and, as such, it is easier to cause the sheet **10** to distend.

The third heater **163** is disposed below the conveyance surface **126***a* of the conveyor belt **126**, downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Specifically, the third heater **163** is provided between the outgoing portion and the return portion of the conveyor belt **126**, on the discharge port **105***b* side (the −X side) of the housing **105**.

More specifically, the third heater **163** is attached and fixed to a surface of the lower side of the guide **122** that supports the outgoing portion of the conveyor belt **126** from the lower side (the −Z side). When the third heater **163** emits heat, the guide **122** is heated and that heat transmits to the outgoing portion of the conveyor belt **126**. As a result, the conveyor belt **126** is heated.

The fourth heater **164** is disposed above the conveyance surface **126***a* of the conveyor belt **126**, downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Specifically, as illustrated in FIG. **6**, the fourth heater **164** is provided between the presser belts **131**, **132** provided on both ends in the width direction (Y direction) of the conveyor belt **126**, on the discharge port **105***b* side (the −X side) of the housing **105**.

More specifically, the fourth heater **164** is attached to a non-illustrated metal plate, and is fixed at a position spaced upward from the conveyance surface **126***a* of the conveyor belt **126**. When the fourth heater **164** emits heat, the conveyor belt **126** is heated by that radiant heat.

Since the third heater **163** and the fourth heater **164** are provided downstream from the irradiator **150**, the third heater **163** and the fourth heater **164** apply heat to regions of the conveyor belt **126** that are downstream from the irradiation position of the electromagnetic waves by the irradiator **150**. As such, the shaped object **50**, produced by heating and causing the sheet **10** to distend by the irradiation of the electromagnetic waves, is conveyed from the irradiation position of the electromagnetic waves to the discharge port **105***b* while being held at a constant temperature. Due to this, it is possible to prevent sudden temperature differences from occurring between the newly produced shaped object **50** and the surrounding environment and, as a result, the formation of condensation can be suppressed.

Control Unit **180**

Returning to FIG. **5**, the control unit **180** controls the operations of the various components of the shaping device **100**, including the conveyor **120**, the irradiator **150**, and the heaters **161** to **164** described above. As illustrated in FIG. **8**, the control unit **180** includes a controller **181**, a storage **182**, an input receiver **183**, a display **184**, and an input/output interface **185**. Each of these components is connected to a bus for transmitting signals.

The controller **181** includes a central processing unit (CPU), read only memory (ROM), and random access memory (RAM). In one example, the CPU is a microprocessor or the like and is a central processing unit that executes a variety of processing and computations. In the controller **181**, the CPU reads a control program stored in the ROM and controls the operations of the entire shaping device **100** while using the RAM as working memory. The controller **181** sends control commands via the input/output interface **185** to the various components, namely the conveyor **120**, the irradiator **150**, and the heaters **161** to **164**, and causes these various components to operate.

The storage **182** is nonvolatile memory such as flash memory or a hard disk. Data and programs to be executed by the controller **181** are stored in the storage **182**.

The input receiver **183** includes an input device such as various types of buttons, a touch pad, a touch panel, or the like, and receives operation inputs (user operations) from a user. For example, the user can set the type of shaped object **50** to be produced, the type of sheet **10** to be used to produce that shaped object **50**, or the like by operating the input receiver **183**.

The display **184** includes a display device such as a liquid crystal display, an organic electro luminescence (EL) display, or the like, and displays various images on the basis of commands from the controller **181**. For example, the display **184** displays a setting screen for producing the shaped object **50** on the sheet **10**.

The input/output interface **185** is an interface for inputting and outputting signals sent and received to and from the controller **181** and the various components of the shaping device **100**.

Production Processing of Shaped Object

Next, the flow of production processing of the shaped object **50** is described while referencing the flowchart illustrated in FIG. **9**.

When the production processing of the shaped object **50** illustrated in FIG. **9** starts, firstly, the sheet **10** is prepared (step S**10**). Specifically, a coating liquid obtained by mixing the binder **31** and the thermally expansive material **32** is screen printed on the first main surface **22** of the base **20**, and the printed coating liquid is dried. As a result, a sheet **10** such as illustrated in FIG. **1** in which the thermally expansive layer **30** is laminated on the first main surface **22** of the base **20** is produced.

After the sheet **10** is prepared, the heat conversion layer **40** is printed on the prepared sheet **10** (step S**20**). Specifically, a printing device prints ink containing the heat conversion material in a gray-scale pattern corresponding to the unevennesses **52** on at least one of the surface of the front side (that is, the front surface of the thermally expansive layer **30**) of the sheet **10** or the surface of the back side (that is, the second main surface **24** of the base **20**) of the sheet **10**. In one example, the printing device is an ink jet printer.

When the heat conversion layer **40** is printed on the sheet **10**, the heaters **161** to **164** functioning as heating units heat the conveyor belt **126** (step S**30**). Specifically, the heaters **161** to **164** operate on the basis of commands from the controller **181** and heat the conveyor belt **126** to a temperature lower than the expansion temperature of the sheet **10**.

When the conveyor belt **126** is heated, the sheet **10** is placed on the heated conveyor belt **126** and conveyed (step S**40**). Specifically, the user inserts the sheet **10**, on which the heat conversion layer **40** is printed, through the loading port **105***a* of the shaping device **100**. In a case in which the heat conversion layer **40** is printed on the surface of the front side of the sheet **10**, the user inserts the sheet **10** through the loading port **105***a* with the surface of the front side facing upward. In a case in which the heat conversion layer **40** is printed on the surface of the back side of the sheet **10**, the user inserts the sheet **10** through the loading port **105***a* with the surface of the back side facing upward. The conveyor **120** operates on the basis of the control of the controller **181** and causes the driving roller **124***b* to rotate, thereby causing the conveyor belt **126** that is heated by the heaters **161** to **164** to run. As a result, the conveyor belt **126** conveys the inserted sheet **10** along the conveyance route R.

When the sheet **10** is conveyed, the sheet **10** being conveyed is irradiated with the electromagnetic waves (step **S50**). Specifically, the irradiator **150** operates on the basis of the control of the controller **181**, and emits the electromagnetic waves toward the sheet **10** that is being conveyed by the conveyor **120**. As a result, the heat conversion layer **40** printed on the sheet **10** converts the electromagnetic waves to heat, thereby generating heat. When the thermally expansive material **32** included in the thermally expansive layer **30** is heated by the heat emitted from the heat conversion layer **40** to the temperature at which expansion starts, the thermally expansive layer **30** starts to expand and the unevennesses **52** are formed. As a result, the shaped object **50** is produced.

Thus, the shaped object **50** is produced from the sheet **10**. The produced shaped object **50** is conveyed along the conveyance route R by the conveyor **120**, and discharged through the discharge port **105***b* of the shaping device **100**. At this time, as desired, a color image may be printed by a printing device on the surface of the front side or the surface of the back side of the sheet **10** in order to enhance the decorativeness of the produced shaped object **50**.

Note that, in cases in which the heat conversion layer **40** is printed on both the surface of the front side and the surface of the back side of the sheet **10** to cause the sheet **10** to distend, the heat conversion layer **40** is printed on each of the surface of the front side and the surface of the back side, and the processing of steps **S20** to **S50** is repeated.

As described above, the shaping device **100** according to Embodiment 1 includes the conveyor belt **126** on which the sheet **10**, which distends due to being irradiated with electromagnetic waves, is placed and conveyed, the irradiator **150** that irradiates the electromagnetic waves on the sheet **10** that is placed on the conveyor belt **126** and is being conveyed, and the heaters **161** to **164** that heat the conveyor belt **126**. Thus, the shaping device **100** according to Embodiment 1 heats uses the heaters **161** to **164** to heat the conveyor belt **126** on which the sheet **10** is placed and conveyed. As such, when the sheet **10** is irradiated with the electromagnetic waves by the irradiator **150**, effects of the surrounding environment of the shaping device **100** can be reduced, and the sheet **10** can be caused to distend in a stable temperature environment. As a result, it is possible to form the unevennesses **52** in the sheet **10** with high precision, which leads to producing the desired shaped object **50** with high precision.

In particular, the shaping device **100** according to Embodiment 1 includes the first heater **161** and the second heater **162** upstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Due to this, the sheet **10** is pre-heated prior to being irradiated with the electromagnetic waves. As a result, when irradiating with the electromagnetic waves by the irradiator **150**, the time required for the temperature of the sheet **10** to reach the predetermined expansion temperature or higher can be shortened. As such, it is easier to cause the sheet **10** to distend. Note that, in addition to using the various heaters to preheat the conveyor belt **126** in advance, the various heaters may be used to heat the sheet **10** and the conveyor belt **126** while conveying the sheet **10**. That is, in addition to using the various heaters to heat the conveyor belt **126** in advance, the second heater **162**, the fourth heater **164**, and the like, may be used to directly heat the sheet **10** without involving the guide or the belt.

Furthermore, the shaping device **100** according to Embodiment 1 includes the third heater **163** and the fourth heater **164** downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. Due to this, the region of the conveyor belt **126** conveying the shaped object **50** produced from the sheet **10** is heated and, therefore, the shaped object **50**, which is produced by heating the sheet **10** to the predetermined expansion temperature or higher, does not suddenly cool. As a result, the formation of condensation on the shaped object **50** can be suppressed.

Embodiment 2

Next, Embodiment 2 of the present disclosure is described. In Embodiment 2, as appropriate, descriptions of configurations and functions that are the same as described in Embodiment 1 are forgone.

The shaping device **100** according to Embodiment 1 includes the heaters **161** to **164** that heat the conveyor belt **126**. However, in some cases, the temperature of the conveyor belt **126** cannot be stabilized with only the heating by the heaters **161** to **164**. For example, the temperature of the conveyor belt **126** may continue to rise. If the temperature of the conveyor belt **126** is not stable, there is a possibility that the bumps cannot be appropriately formed due to the sheet **10** distending excessively, the boundaries between the protrusions and the recesses becoming unclear, or the like. As such, in Embodiment 2, the temperature of the conveyor belt **126** that is heated by the heaters **161** to **164** is adjusted so as to maintain suitable temperature conditions.

FIG. **10** illustrates the configuration of a shaping device **200** according to Embodiment 2. The shaping device **200** includes the conveyor **120**, the tensioner **130**, the irradiator **150**, the heaters **161** to **164**, and the control unit **180**. These components are the same as those of the shaping device **100** according to Embodiment 1 and, as such, descriptions thereof are foregone.

In addition to the components that are the same as in Embodiment 1, the shaping device **200** according to Embodiment 2 further includes a piping **211** for circulating water, and fans **221** to **223** that blow air. Note that, in FIG. **10**, to facilitate comprehension, only a portion of the piping **211** is denoted with a reference numeral. However, all of the portion marked by diagonal lines in FIG. **10** represents a cross-section of the piping **211**.

Piping **211**

The piping **211** functions as a first temperature adjuster that adjusts, using water that flows in the piping **211**, the temperature of the conveyor belt **126** that is heated by the heaters **161** to **164**. As illustrated in FIG. **10**, the piping **211** is disposed so as to pass through the inner side of the conveyor belt **126**. In this case, the inner side of the conveyor belt **126** corresponds to between the outgoing portion and the return portion of the conveyor belt **126**. The piping **211** circulates cold water or hot water on the inner side of the conveyor belt **126** to cool or heat the conveyor belt **126**. The water that flows inside the piping **211** is an example of a thermal medium.

More specifically, the piping **211** is attached to the lower surface of the guide **122**, which is below the conveyance surface **126***a* of the conveyor belt **126**. In this case, as in

Embodiment 1, the guide **122** is a member that supports the conveyor belt **126**. The upper surface of the guide **122** contacts the lower surface of the conveyor belt **126**. Since the piping **211** is attached to the guide **122**, when the cold water or hot water flows through the piping **211**, the guide **122** is cooled or heated first. When the guide **122** is cooled or heated, the heat of the guide **122** transmits to the conveyor belt **126**, and the conveyor belt **126** is cooled or heated.

FIG. **11** illustrates an arrangement example of the piping **211** disposed below the conveyance surface **126***a*, viewed from above (the +Z direction). In FIG. **11**, to facilitate comprehension, the position of the conveyance surface **126***a* of the conveyor belt **126** is indicated by dashed lines, and the tensioner **130**, the irradiator **150**, and the other components are omitted.

The piping **211** is routed on the lower surface of the guide **122** so as to be distributed across a wide area of the conveyor belt **126** from upstream to downstream in the conveyance direction of the conveyor belt **126**. As in Embodiment 1, in this case, the conveyance direction of the conveyor belt **126** corresponds to from the +X side to the −X side, that is, the −X direction.

More specifically, on the inner side of the conveyor belt **126**, the piping **211** passes at least positions upstream and downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**, and a position facing the irradiator **150** across the conveyance surface **126***a* of the conveyor belt **126**. The piping **211** is disposed so as to go out and return at least one time in the width direction (the Y direction) of the conveyor belt **126** at each of farther upstream than the first heater **161**, farther downstream than the third heater **163**, and between the first heater **161** and the third heater **163**.

Additionally, as illustrated in FIG. **11**, the shaping device **200** further includes a water supplier **212** that supplies water to the piping **211**. The water supplier **212** is disposed at an appropriate position such as to the side of or below the conveyor belt **126**, inside the housing **105**, or outside the housing **105**. Note that, it is preferable that the water supplier **212** is disposed outside the housing **105** in order to prevent the effects of the heat of the water supplier **212** itself that is generated as a result of the water supplier **212** operating.

The water supplier **212** includes a function for cooling water to produce cold water, and a function for heating water to produce hot water. The water supplier **212** mixes the produced cold water and hot water to produce water having a temperature adjusted to a desired temperature, and supplies the temperature-adjusted water to the piping **211**. The piping **211** circulates the water supplied from the water supplier **212**. Note that the type of the water supplier **212** is not particularly limited provided that the water supplier **212** can perform temperature adjustment from cold water to hot water. Examples thereof include air-cooled and water-cooled types.

When cold water or hot water is supplied from the water supplier **212** to the piping **211**, as illustrated by the arrows in FIG. **11**, the cold water or hot water is firstly fed to the upstream side in the conveyance direction, and flows so as to repeatedly cross the conveyor belt **126** on the upstream side. Thereafter, the cold water or hot water in the piping **211** is fed from the upstream side to a center section and the downstream side, and flows so as to repeatedly cross the conveyor belt **126** at the center section and on the downstream side.

Thus, the cold water or hot water in the piping **211** repeatedly goes out and returns in the width direction of the conveyor belt **126**, thereby making it possible to carry out temperature adjustments more efficiently.

More specifically, the water supplier **212** drives on the basis of the control of the controller **181** of the control unit **180**, and adjusts the temperature of the water supplied to the piping **211** in accordance with the temperature of the conveyor belt **126** heated by the heaters **161** to **164**. Specifically, when the temperature of the conveyor belt **126** heated by the heaters **161** to **164** is higher than a reference temperature, the water supplier **212** cools the conveyor belt **126** by supplying cold water to the piping **211**. When the temperature of the conveyor belt **126** heated by the heaters **161** to **164** is lower than the reference temperature, the water supplier **212** heats the conveyor belt **126** by supplying hot water to the piping **211**.

In this case, the reference temperature is a temperature of the conveyor belt **126** that causes the sheet **10** to suitably distend, and is preset to an appropriate temperature such as 55° C. or the like. Note that the reference temperature is not limited to one temperature, and may be a certain range such as, for example, from 52° C. to 58° C.

Here, the temperature of the conveyor belt **126** is measured by a non-illustrated temperature sensor. In one example, the temperature sensor is a contact-type sensor that senses the temperature using a thermocouple. The temperature sensor may be provided at any position where it is possible to measure the temperature of the conveyor belt **126**. In one example, the temperature sensor is provided at a position heated by the first heater **161** and the second heater **162**, below the conveyance surface **126***a* of the conveyor belt **126**. Note that the temperature sensor is not limited to being provided at one location, and may be provided at a plurality of locations. Information of the temperature measured by the temperature sensor is supplied to the control unit **180** via a non-illustrated communication line. The controller **181** of the control unit **180** adjusts, in accordance with the temperature measured by the temperature sensor, the temperature of the water to be supplied to the piping **211** from the water supplier **212**.

Note that the temperature sensor is not limited to a contact-type sensor, and may be a non-contact-type sensor. In a case in which the temperature sensor is a non-contact-type sensor, the temperature sensor is, for example, an infrared sensor that senses the temperature of the conveyance surface **126***a* of the conveyor belt **126** by infrared rays. In such a case, the temperature sensor is disposed at a position facing the conveyance surface **126***a* so as to be able to sense the temperature of the conveyance surface **126***a*. The temperature sensor may be provided at a plurality of locations instead of at one location.

The water supplier **212** lowers the temperature of the water to be supplied to the piping **211** when the temperature of the conveyor belt **126** heated by the heaters **161** to **164** is higher, and raises the temperature of the water to be supplied to the piping **211** when the temperature of the conveyor belt **126** heated by the heaters **161** to **164** is lower. Due to this, the piping **211** circulates colder water when the temperature of the conveyor belt **126** is higher, and circulates hotter water when the temperature of the conveyor belt **126** is lower.

Specifically, the water supplier **212** references the temperature adjustment table illustrated in FIG. **12** to determine the temperature of the water to be supplied to the piping **211**. The temperature adjustment table illustrated in FIG. **12** illustrates, as one example, the correspondence between the temperature of the conveyor belt **126** and the water temperature inside the piping **211** when the reference temperature is 55° C. The temperature adjustment table is set in advance, and is stored in the storage **182**.

For example, in a case in which the temperature of the conveyor belt **126** is 60° C., which is 5° C. higher than the reference temperature, the water supplier **212** adjusts the temperature of the water to be supplied to the piping **211** to 50° C. by lowering the temperature of the water by 5° C. In a case in which the temperature of the conveyor belt **126** is 65° C., which is 10° C. higher than the reference temperature, the water supplier **212** adjusts the temperature of the water to be supplied to the piping **211** to 45° C. by lowering the temperature of the water by 10° C. In a case in which the temperature of the conveyor belt **126** is 70° C., which is 15° C. higher than the reference temperature, the water supplier **212** adjusts the temperature of the water to be supplied to the piping **211** to 40° C. by lowering the temperature of the water by 15° C.

In a case in which the temperature of the conveyor belt **126** is 50° C., which is 5° C. lower than the reference temperature, the water supplier **212** adjusts the temperature of the water to be supplied to the piping **211** to 60° C. by raising the temperature of the water to be supplied to the piping **211** by 5° C. In a case in which the temperature of the conveyor belt **126** is 45° C., which is 10° C. lower than the reference temperature, the water supplier **212** adjusts the temperature of the water to be supplied to the piping **211** to 65° C. by raising the temperature of the water to be supplied to the piping **211** by 10° C. In a case in which the temperature of the conveyor belt **126** is 40° C., which is 15° C. lower than the reference temperature, the water supplier **212** adjusts the temperature of the water to be supplied to the piping **211** to 70° C. by raising the temperature of the water to be supplied to the piping **211** by 15° C.

Thus, in cases in which the temperature of the conveyor belt **126** has risen or decreased, the water supplier **212** lowers or raises the temperature of the water to be supplied to the piping **211** an amount corresponding to the rise or decrease of the temperature. As a result, the temperature of the conveyor belt **126** can be maintained at the reference temperature. In particular, the temperature may rise excessively when attempting to heat the conveyor belt **126** to the reference temperature using the heaters. As such, in cases in which the temperature of the conveyor belt **126** is lower than the reference temperature, the temperature adjuster can adjust the temperature more accurately than when adjusting the temperature using the heaters.

Fans **221** to **223**

Returning to FIG. **10**, the fans **221** to **223** blow toward the conveyor belt **126**, thereby functioning as a second temperature adjuster that adjusts the temperature of the conveyor belt **126** that is heated by the heaters **161** to **164**. The fans **221** to **223** are disposed on the inner side of the conveyor belt **126**, facing up toward the lower surface of the guide **122**. The fans **221** to **223** blow cold air or hot air toward the conveyor belt **126** to cool or heat the conveyor belt **126**.

A first fan **221** is disposed upstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. More specifically, the first fan **221** is disposed below the guide **122** farther upstream than the first heater **161**.

A second fan **222** is disposed downstream from the irradiator **150** in the conveyance direction of the conveyor belt **126**. More specifically, the second fan **222** is disposed below the guide **122** farther downstream than the third heater **163**.

A third fan **223** is disposed at a position facing the irradiator **150** across the conveyance surface **126***a* of the conveyor belt **126**. More specifically, the third fan **223** is disposed below the peak T of the conveyance route R.

The fans **221** to **223** are driven on the basis of control of the controller **181**, and blow air from below the guide **122**. As a result, the temperature of the guide **122** is adjusted, thereby further adjusting the temperature of the conveyor belt **126** via the guide **122**. The three fans **221** to **223** are disposed upstream, downstream, and in the center section of the conveyor belt **126**. As such, it is possible to adjust the temperature of the conveyor belt **126** so as to maintain the temperature of the entire conveyor belt **126** as constantly as possible.

As illustrated in FIG. **10**, the shaping device **200** further includes fan heaters **231** to **233**. The fan heaters **231** to **233** heat the air to be blown by the fans **221** to **223**.

More specifically, the fan heaters **231** to **233** are respectively disposed below the fans **221** to **223**, that is, on the windward side of the fans **221** to **223**. When driven by commands from the controller **181**, the fan heaters **231** to **233** heat the air on the windward side of the fans **221** to **223**. When the fans **221** to **223** are driven while the fan heaters **231** to **233** heat the air, hot air is blown on the guide **122**. As a result, the conveyor belt **126** is heated. Meanwhile, if the fans **221** to **223** are driven while the fan heaters **231** to **233** are not driven, cold air is blown on the guide **122**. As a result, the conveyor belt **126** is cooled.

The fans **221** to **223** and the fan heaters **231** to **233** are driven of the basis of control of the controller **181** of the control unit **180**, and adjust, in accordance with the temperature of the conveyor belt **126** heated by the heaters **161** to **164**, the temperature of the air to be blown.

Here, the temperature of the conveyor belt **126** is measured by the same temperature sensor used in the temperature adjusting by the piping **211**. The controller **181** controls the fans **221** to **223** and the fan heaters **231** to **233** in accordance with the temperature of the conveyor belt **126** measured by the temperature sensor.

Specifically, in a case in which the temperature of the conveyor belt **126** heated by the heaters **161** to **164** is higher than the reference temperature, the controller **181** causes the fans **221** to **223** to blow without driving the fan heaters **231** to **233**. As a result, the fans **221** to **223** blow cold air toward the conveyor belt **126** and cool the conveyor belt **126** to the reference temperature.

Meanwhile, in a case in which the temperature of the conveyor belt **126** heated by the heaters **161** to **164** is lower than the reference temperature, the controller **181** drives the fan heaters **231** to **233** and also causes the fans **221** to **223** to blow. As a result, the fans **221** to **223** blow air heated by the fan heaters **231** to **233** toward the conveyor belt **126** and heat the conveyor belt **126** to the reference temperature.

More specifically, when cooling the conveyor belt **126**, the controller **181** changes the number of rotations per unit time of the fans **221** to **223** in accordance with the temperature of the conveyor belt **126** measured by the temperature sensor, thereby adjusting the strength of the blowing. Specifically, in cases in which the temperature of the conveyor belt **126** is higher, the number of rotations per unit time of the fans **221** to **223** is increased and the fans **221** to **223** blow stronger. In cases in which the temperature of the conveyor belt **126** is lower, the number of rotations per unit time of the fans **221** to **223** is decreased and the fans **221** to **223** blow weaker.

Thus, the temperature of the conveyor belt **126** can be maintained at the reference temperature by controlling the number of rotations per unit time of the fans **221** to **223**. Note that the correspondence between the temperature of the conveyor belt **126** and the number of rotations per unit time is predetermined in a manner similar to the temperature adjustment table illustrated in FIG. **12**, and is stored in the storage **182**. When both heating and cooling, non-illustrated vents, fans, and the like are appropriately provided so that the heated air is not trapped in the housing **105**, and the temperature can be more precisely adjusted by venting the heated air out of the housing **105**.

As described above, the shaping device **200** according to Embodiment 2 includes the piping **211** that circulates water and the fans **221** to **223** that blow air as temperature adjusters that adjust the temperature of the conveyor belt **126** heated by the heaters **161** to **164**. Due to this, the temperature of the conveyor belt **126** can be prevented from rising excessively or decreasing excessively, and the sheet **10** can be caused to distend in a more stable temperature environment. As a result, it is possible to form the unevennesses **52** in the sheet **10** with high precision, which leads to producing the desired shaped object **50** with high precision.

MODIFIED EXAMPLES

Embodiments of the present disclosure are described above, but these embodiments are merely examples and do not limit the scope of application of the present disclosure. That is, various applications of the embodiments of the present disclosure are possible, and all embodiments are included in the scope of the present disclosure.

For example, in Embodiments 1 and 2, the shaping device **100**, **200** includes, as the heating unit that heats the conveyor belt **126**, the four heaters **161** to **164**. However, it is sufficient that the shaping device **100**, **200** includes, as the heating unit, at least one heater that heats the conveyor belt **126**. In this case, the position at which the at least one heater is disposed may be upstream or downstream with respect to the irradiator **150**, and may be above or below the conveyance surface **126***a*. When any position of the conveyor belt **126** is heated by the at least one heater, the heat from the heating transmits to the interior of the conveyor belt **126** and, as a result, the entire conveyor belt **126** is warmed. Accordingly, it is possible to maintain, at constant conditions, the temperature environment when irradiating the sheet **10** with the electromagnetic waves, and the sheet **10** can be caused to distend in a stable temperature environment.

In Embodiment 2, the shaping device **200** includes, as the temperature adjuster, the piping **211** and the fans **221** to **223**. However, a configuration is possible in which the shaping device **200** includes, as the temperature adjuster, only one of the piping **211** and the fans **221** to **223**. Including both of these components allows the shaping device **200** to more effectively adjust the temperature of the conveyor belt **126**. For example, it is preferable that devices such as large heaters that generate a relatively large amount of heat include both the piping **211** and the fans **221** to **223** because such a configuration enables more effective cooling. However, it is possible to adjust the temperature of the conveyor belt **126** that is heated by the heaters **161** to **164** using only one of the piping **211** and the fans **221** to **223**. It is preferable that devices such as small heaters that generate a relatively small amount of heat include only one of the piping **211** and the fans **221** to **223** because such a configuration enables temperature adjustments to be carried out in a manner that is sufficiently effective.

In Embodiment 2, the shaping device **200** includes the three fans **221** to **223** on the inner side of the conveyor belt **126**. However, the fans **221** to **223** are not limited to being provided on the inner side of the conveyor belt **126**, and may be provided at any position provided that the fans **221** to **223** can blow air on the conveyor belt **126**. Additionally, the number of the fans is not limited to three. The fan heaters **231** to **233** are not limited to being disposed on the windward side of the fans **221** to **223**, and may be disposed on the downwind side of the fans **221** to **223** provided that the fan heaters **231** to **233** can heat the air blown by the fans **221** to **223**. Additionally, the piping **211** is not limited to being disposed so as to go out and return along the width direction of the conveyor belt **126**, as illustrated in FIG. **11**. For example, a configuration is possible in which the piping **211** is disposed so as to go out and return along the conveyance direction of the conveyor belt **126**.

In Embodiment 2, the piping **211** circulates water to adjust the temperature of the conveyor belt **126** that is heated by the heaters **161** to **164**. However, the thermal medium flowing inside the piping **211** is not limited to water, and may be a liquid other than water or a gas. For example, a configuration is possible in which a thermal medium supplier corresponding to the water supplier **212** supplies and circulates, as the thermal medium, a liquid other than water or a gas that corresponds to the appropriate use temperature to the piping **211**, thereby heating or cooling the conveyor belt **126** that is heated by the heaters **161** to **164**.

In Embodiments 1 and 2, the conveyor **120** conveys the sheet **10** along the conveyance route R that is convexly curved. However, the conveyor **120** may convey the sheet **10** along any conveyance route, not only the convexly curved conveyance route R.

As an example, FIG. **13** illustrates a configuration of a shaping device **100***a* according to a modified example of Embodiment 1. As illustrated in FIG. **13**, the shaping device **100***a* includes a conveyor **120***a* that includes the conveyor belt **126** on which the sheet **10** is placed and conveyed and that conveys the sheet **10** along a flat conveyance route R', the irradiator **150** that irradiates electromagnetic waves on the sheet **10** that is placed on and being conveyed by the conveyor belt **126**, and the heaters **161** to **164** that heat the conveyor belt **126**. Since the conveyance route R' of the shaping device **100***a* is flat, the conveyor **120***a* does not include the guide **122** and the tension roller **124***c* that cause the conveyor belt **126** to convexly curve. Thus, even in a case in which the sheet **10** is conveyed along the flat conveyance route R', the irradiator **150** can cause the sheet **10** to distend in a stable temperature environment by heating the conveyor belt **126** using the heaters **161** to **164**.

FIG. **14** illustrates a configuration of a shaping device **200***a* according to a modified example of Embodiment 2. In addition to the configuration of the shaping device **100***a* illustrated in FIG. **13**, the shaping device **200***a* includes the piping **211**, the water supplier **212** (not illustrated in the drawings), the fans **221** to **223**, and the fan heaters **231** to **233**. These components are the same as those described in Embodiment 2. In Embodiment 2, the conveyance route R is convexly curved, but in FIG. **14**, the various components are disposed so as to fit to the flat conveyance route R'. Note that the guide **122** and the tension roller **124***c* may be provided even when the conveyance route R' is flat such as in FIGS. **13** and **14**. Thus, even when the conveyance route R' is flat, as in Embodiment 2, the temperature of the conveyor belt **126** heated by the heaters **161** to **164** can be adjusted using the piping **211** or the fans **221** to **223** so as to maintain suitable temperature conditions.

Even when the conveyance route R is convexly curved such as in Embodiments 1 and 2, the shaping device **100**, **200** may include the guide **122**. That is, while it is preferable that the guide **122** contact the entire surface of the outgoing portion inner side of the conveyor belt **126** so as to cause the conveyance route R convexly curve, provided that the conveyance route R can be caused to convexly curve, the guide **122** may be omitted. For example, a configuration is possible in which the conveyor belt **126** is supported at the minimal positions such as two locations on both ends in the width direction (the Y direction) of the peak T of the convexly curved conveyance route R. Moreover, a configuration is possible in which a plurality of heaters is disposed along the convexly curved conveyance route R, and the plurality of heaters directly heats or cools the inner side of the conveyor belt **126** without involving the guide **122**.

A configuration is possible in which a guide that supports the presser belts **131**, **132** is provided on the inner side of the tensioner **130**. Furthermore, a configuration is possible in which a temperature sensor is provided on the inner side of the tensioner **130**, and the temperature sensor measures the temperature of the guide provided on the inner side of the tensioner **130** to indirectly measure the temperature of the conveyor belt **126**. Moreover, a configuration is possible in which the guide is heated by a heater to transmit heat to the tensioner **130**.

In Embodiments 1 and 2, the sheet **10** includes the base **20** and the thermally expansive layer **30**. However, the sheet **10** described above in the Embodiments is merely an example, and a variety of sheets **10** with different layer configurations, sizes, thicknesses, and the like can be used. For example, a configuration is possible in which the sheet **10** includes an ink receiving layer that absorbs and receives ink. The ink receiving layer is formed from a material suitable for holding printing ink, toner, and the like on the surface of the ink receiving layer. Alternatively, the sheet **10** may include a layer made from another desired material.

In Embodiments 1 and 2, in the controller **181**, the CPU executes the program stored in the ROM to control the various components of the shaping device **100**, **200**. However, in the present disclosure, the controller **181** may include, for example, an Application Specific Integrated Circuit (ASIC), a Field-Programmable Gate Array (FPGA), various control circuitry, or other dedicated hardware instead of the CPU, and this dedicated hardware may control the various components of the shaping device **100**. In this case, the various functions of the controller **181** may be realized by individual pieces of hardware, or the various functions of the controller **181** may be collectively realized by a single piece of hardware. Additionally, the various functions may be realized in part by dedicated hardware and in part by software or firmware.

The foregoing describes some example embodiments for explanatory purposes. Although the foregoing discussion has presented specific embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the broader spirit and scope of the invention. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense. This detailed description, therefore, is not to be taken in a limiting sense, and the scope of the invention is defined only by the included claims, along with the full range of equivalents to which such claims are entitled.

What is claimed is:

1. A shaping device, comprising:

a conveyor belt wound on driving rollers within a housing and on which a sheet is placed for conveyance along a convexly curved route extending from a loading port to a discharge port of the housing, the sheet distending due to being irradiated with electromagnetic waves to form a three-dimensional image;

an irradiator that irradiates the electromagnetic waves on the sheet placed on the conveyor belt; and

at least one heater that heats the conveyor belt, the shaping device maintaining a constant temperature of the entire conveyor belt within the housing.

2. The shaping device according to claim **1**, further comprising:

on an inner side of the conveyor belt, a guide that supports the conveyor belt and that conducts heat with the conveyor belt.

3. The shaping device according to claim **1**, wherein

the at least one heater is disposed at least upstream from the irradiator with respect to a conveyance direction of the conveyor belt.

4. The shaping device according to claim **3**, wherein the at least one heater comprises a first heater disposed below a conveyance surface of the conveyor belt and a second heater disposed above the conveyance surface, the first heater and the second heater being disposed upstream from the irradiator with respect to the conveyance direction.

5. The shaping device according to claim **4**, further comprising:

a third heater disposed below the conveyance surface and a fourth heater disposed above the conveyance surface, the third heater and the fourth heater being disposed downstream from the irradiator with respect to the conveyance direction.

6. The shaping device according to claim **3**, wherein the at least one heater further comprises at least one heater disposed downstream from the irradiator with respect to the conveyance direction.

7. The shaping device according to claim **1**, further comprising:

a temperature adjuster that adjusts a temperature of the conveyor belt heated by the at least one heater.

8. The shaping device according to claim **7**, wherein the temperature adjuster is configured to cool the conveyor belt when the temperature of the conveyor belt heated by the at least one heater is higher than a reference temperature, and is configured to heat the conveyor belt when the temperature of the conveyor belt heated by the at least one heater is lower than the reference temperature.

9. The shaping device according to claim **8**, wherein the temperature adjuster comprises a piping passing through an inner side of the conveyor belt and circulating a thermal medium, and wherein the piping circulates the thermal medium in a condition having a temperature lower than the reference temperature when the temperature of the conveyor belt heated by the at least one heater is higher than the reference temperature, and circulates the thermal medium in a condition having a temperature higher than the reference temperature when the temperature of the conveyor belt heated by the at least one heater is lower than the reference temperature.

10. The shaping device according to claim **7**, wherein the temperature adjuster comprises a piping that passes through an inner side of the conveyor belt and that circulates a thermal medium.

11. The shaping device according to claim **10**, wherein, on the inner side of the conveyor belt, the piping passes through at least positions upstream and downstream from the irradiator with respect to the conveyance direction of the conveyor belt, and through a position facing the irradiator across a conveyance surface of the conveyor belt.

12. The shaping device according to claim **7**, wherein the temperature adjuster comprises at least one fan that blows toward the conveyor belt.

13. The shaping device according to claim 12, wherein the at least one fan comprises a first fan disposed upstream from the irradiator with respect to the conveyance direction of the conveyor belt, a second fan disposed downstream from the irradiator with respect to the conveyance direction, and a third fan disposed at a position facing the irradiator across a conveyance surface of the conveyor belt.

14. The shaping device according to claim 12, further comprising:

a fan heater that heats air blown by the at least one fan; wherein

the at least one fan blows the air heated by the fan heater toward the conveyor belt to heat the conveyor belt.

15. The shaping device according to claim 12, wherein the at least one fan is configured to cool the conveyor belt whereby a rotational speed of the at least one fan is changed in accordance with the temperature of the conveyor belt heated by the at least one heater.

16. The shaping device according to claim 1, wherein

the sheet includes

a base,

a thermally expansive layer that is laminated on a first main surface of the base and that expands due to being heated, and

a heat conversion layer that is laminated on at least one of a second main surface of the base or the thermally expansive layer, and that heats the thermally expansive layer by absorbing the electromagnetic waves and converting the electromagnetic waves to heat.

17. The shaping device according to claim 16, wherein

the thermally expansive layer expands as a result of being heated to a predetermined expansion temperature or higher, and

the at least one heater heats the conveyor belt to a temperature lower than the predetermined expansion temperature.

18. A production method for a shaped object using the shaping device according to claim 1, the production method comprising:

heating the conveyor belt;

placing the sheet on the heated conveyor belt, and conveying the sheet; and

irradiating the conveyed sheet with the electromagnetic waves.

19. The production method according to claim 18, wherein

the sheet includes

a base,

a thermally expansive layer that is laminated on a first main surface of the base and that expands due to being heated, and

a heat conversion layer that is laminated on at least one of a second main surface of the base or the thermally expansive layer, and that heats the thermally expansive layer by absorbing the electromagnetic waves and converting the electromagnetic waves to heat.

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